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PROGRESS REPORT

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HORTICULTURAL CROPS RESEARCH

APR 22 1969

of the

UNITED STATES DEPARTMENT OF AGRICULTURE

CURRENT SERIAL RECORDS

This progress report includes a summary of the current research of the USDA on horticultural crops and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1967, and June 30, 1968. Current agricultural research findings are also published in the monthly USDA publications, Agricultural Research and The Farm Index.

RESEARCH PROGRAM DEVELOPMENT AND EVALUATION STAFF

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON, D.C.

December 31, 1968

RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

1. Farm Resources & Facilities	8. Cotton
2. Utilization	9. Grain & Forage Crops
3. Human Nutrition & Consumer Use	10. Horticultural Crops
4. Marketing	11. Oilseed & Peanut Crops
5. Agricultural Economics	12. Plant Science & Entomology
6. Forestry	13. Sugar
7. Animal & Animal Products	14. Tobacco

The source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number prefixes shown below refer to advisory committees listed above.

ORGANIZATIONAL UNIT PROGRESS REPORTS

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Consumer & Food Economics
- 4 - Market Quality
- 4 - Transportation & Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease & Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 1, 5 - Economic Development
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development & Trade
- 5 - Foreign Regional Analysis
- 5 - Natural Resource Economics
- 6 - Forest Service - Research (FS)
- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

- 6 - Forestry (other than Forest Service)
- 7 - Animal-Poultry & Products Research other than Husbandry, Disease and Parasite
- 8 - Cotton and Cottonseed
- 9 - Grain and Forage Crops
- 10 - Horticultural Crops
- 11 - Oilseed and Peanut Crops
- 13 - Sugar
- 14 - Tobacco

A copy of any of the reports may be requested from W. C. Dachtler, Head, Research Advisory Committee Staff, Research Program Development and Evaluation Staff, U.S. Department of Agriculture, Washington, D.C. 20250.

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INTRODUCTION

This report deals with research related to production, processing, distribution, and use of citrus, deciduous, subtropical, and small fruits; potatoes and vegetables; edible tree nuts; flowers and nursery plants; woody ornamentals; and trees for shade and farm windbreaks. It does not include extensive cross-commodity work, much of it is basic in character, which contributes to the solution of problems of other agricultural commodities, as well as horticultural crops. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

The report is organized by "Problem Areas" which are shown in the table of contents. For each area there is (1) a tabulation of the number and location of the scientist man-years involved in research by USDA, (2) a statement of the research problem and objectives, (3) a summary of progress during the past year, and (4) a list of publications resulting from USDA and cooperative work.

Research on horticultural crops is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

Research by USDA

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting, and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Research Divisions of the Agricultural Research Service.

Nutrition, Consumer and Industrial Use Research. Nutrition and consumer use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service. Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms or combinations of food products. It is also concerned with improved equipment and processes. The work is done by the Eastern, Southern, and Western Utilization Research and Development Divisions of the Agricultural Research Service.

Marketing and Economic Research. Research by the Market Quality Division, Agricultural Research Service, deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of agricultural commodities, and the development of new methods and devices for evaluation of quality.

Transportation and marketing facilities research is concerned with methods and material used in marketing and transporting farm and food products from the farm to the consumer. This research is done by the Transportation and Facilities Research Division, Agricultural Research Service.

Research pertaining to marketing economics is conducted by researchers in two agencies. The Farmer Cooperative Service deals with the cooperative aspects of marketing. The Marketing Economics Division, Economic Research Service, conducts studies on the physical efficiency and performance of the marketing system with respect to (a) farmers, (b) marketers, and (c) consumers and transportation and interregional competition. Identification and measurement of relationships affecting supply, demand, and price of horticultural crop and commodity situation and outlook analysis are a part of the research in Economic and Statistical Analysis Divisions, Economic Research Service.

Research on the behavior, opinions, and preferences of consumers which affect their purchase and use of agricultural products or end products is conducted by the Standards and Research Division, Agricultural Research Service.

Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and Industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by food processors and distributors, food industry and trade associations, food container and equipment suppliers, marketing equipment and facility manufacturers, chemical and fertilizer companies, package and container manufacturers, market research institutes and corporations, nurserymen, orchardists, and

producers. Industry's cooperation in supporting research on horticultural crops in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State Stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried horticultural products. The canning, freezing, and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at USDA laboratories, universities, and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizable contributions to research on the development of equipment for handling horticultural crops on the farm, in orchards, or in greenhouses; into and out of packing houses, transportation vehicles, and wholesale distribution centers; and in the retail establishment. They also conduct research on the containers in which the products are moved and on the transportation vehicles from which it moves from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and interregional and intermarket competition.

Chemical, fertilizer, and electrical companies make significant research contributions in the development of new materials, or combinations of materials, to produce more efficiently high quality horticultural commodities, through better plant nutrition; improved disease, insect, nematode, and weed control; and the regulation of growth processes by the use of growth regulator substances and other chemicals, light, and environmental control.

There are a few private breeders of horticultural crops and a number of the larger nurserymen, florists, and seedsmen, who spend considerable time and money in the search for and testing of new varieties in the major production areas, sometimes on their own acreage, but usually in cooperation with some grower. The contribution of growers to our overall research effort on horticultural crops is substantial. Certainly, in the field of production their help is indispensable, for most of the laboratory research results must be finally confirmed by larger-scale experiments. The grower cooperates with the USDA, State Experiment Stations, and suppliers of many materials and equipment, usually without compensation except for the experience and knowledge gained.

I. FARM RESEARCH

TREE FRUIT BREEDING, GENETICS, DISEASES,
VARIETAL EVALUATION, PHYSIOLOGY AND CULTURE

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968			Total
	304	Research Problem Area	205	
<u>Apples & Pears</u>				
Maryland (Beltsville)	4.5		2.0	6.5
Georgia	1.0		-	1.0
Indiana	-		-	-
Ohio	1.0		-	1.0
Oregon	-		1.0	1.0
Washington	3.9		0.2	4.1
Wyoming	-		-	-
Total Apples & Pears	10.4		3.2	13.6
<u>Peaches & Other Stone Fruits</u>				
Maryland (Beltsville)	1.2		2.3	3.5
California	0.5		1.0	1.5
Georgia	1.9		0.1	2.0
South Carolina	-		2.0	2.0
Utah	-		1.0	1.0
Washington	1.0		2.0	3.0
Wisconsin	-		-	-
Wyoming	-		-	-
Total Stone Fruits	4.6		8.4	13.0
Total	15.0		11.6	26.6

Intramural program is supplemented by extramural support representing (a) 2.8 SMY's at State Agricultural Experiment Stations^{1/}, (b) no SMY's at other U. S. Institutions, and (c) P.L. 480 funds in 5 countries representing 112,857 U.S. dollars equivalent.

^{1/} RPA 304 1.9; RPA 205 0.9

Problems and Objectives

The deciduous tree fruit industry continually needs quality fruit, reliable and economical disease control, and efficient cultural methods to meet U.S. and world demands for more and better fruit. With today's rapid transportation, all kinds of harvest-fresh fruit are readily available to markets and processors. The consumer has come to expect a variety of high quality fruit in his diet. The grower is often pressed to provide the fruit economically. His production is often limited by harsh winter and spring climates that kill trees or flowers and inherent plant response such as biennial bearing that preclude reliable annual production. He is confronted with losses from pests and the high cost of their control as well as high labor costs for orchard operations, particularly harvesting.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Originating scion kinds and varieties with improved horticultural tree and fruit qualities.
2. Originating rootstock kinds and varieties that are pest resistant and adapted to fruit-area soils and climates.
3. Controlling flowering, fruiting, and growth with rootstocks or with growth-regulating chemicals.
4. Determining etiology and economic control of tree and fruit diseases.
5. Developing orchard management systems to improve fruit yield and quality and reduce costs.

Progress - USDA and Cooperative Program

-- Tree Fruits --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Pears. One collection of seed made from the wild in the USSR in 1967 was particular interest because of the absence of grit cells in the fruit of the parent tree.
2. Peaches and nectarines. At Beltsville, Md., a selection which has been outstanding in the Sandhills of South Carolina is being considered for introduction. Advanced selections are being evaluated in other peach growing regions.

From Byron, Ga., 32 low temperature tolerant selections were distributed to southeastern experiment stations. A Fort Valley, Ga., selection appears to have varietal potential in California where six peach and seven nectarine selections, show commercial promise. At Prosser, Wash., three selections in semi-commercial tests, are being considered for release.

3. Plums. The new plum variety Friar was released at Fresno, Calif. Friar is productive, black when fully mature, has good quality, large fruit size, and is resistant to fruit cracking.

4. Apricots. At Prosser, Wash., two new apricot selections were placed in grower tests.

5. Sweet cherries. At Prosser, a short-internoded mutant was obtained from 'Bing' cuttings irradiated in 1964. Such a short-internode tree will be valuable for its compact growth if the typical Bing fruit characteristics are retained or enhanced.

6. P.L. 480 Research. Research in Poland to evaluate East European and Asiatic fruit species of potential interest to U.S. fruit breeders has resulted in several introductions. Some promising late-blooming apricots, and hardy peaches, apples, and pears are now in quarantine in the U.S. and are being indexed for virus infections.

B. Physiology and Culture

1. Apple nutrition. Leaf analyses from apple trees growing in sand culture plots at Beltsville, Md., indicate that boron influences calcium uptake in apple leaves when there is a proper balance between source and level of nitrogen. Source of nitrogen also had an effect on flowering. None of the trees receiving NO_3 flowered, while 25 percent of the trees receiving NH_4 flowered.

2. Calcium nutrition of apple. Using radio-labelled calcium, it was found that calcium accumulates in the basal portion of older leaves and is not readily translocated to actively growing tissues. Calcium transport in leaves was found to be mostly metabolic but mostly physical in bark tissues. Both boron and nitrate nitrogen were found to increase the uptake of calcium.

3. York-spot disorder of apple. A study of 10 mineral elements in the fruit of the York Imperial apple showed that there were distinct gradients within the fruit. Calcium was found to be much lower in the calyx end of the fruit than in the stem end. This may implicate calcium with the York spot disorder as the disorder is most often found on the calyx end of the fruit. Calcium, magnesium, and boron were found to be higher in the cork tissues but this was interpreted as being the result of the disorder, not the cause. Pectin also was higher in the cork tissues. Respiration and ethylene production was higher in affected tissues. A disorganization of the lipoprotein membranes in the fruit is hypothesized to be the initial physiological change

that leads to the formation of cork tissues.

4. Apple leaf photosynthesis. At Wenatchee, Wash., 21 different surfactant and insecticide chemicals used in commercial fruit growing did not seriously reduce the rate of photosynthesis.

5. Apple pruning research. At Wenatchee, Wash., "stub" pruning was compared with conventional "long" pruning. Return bloom was higher with the stub pruning even though fruit production was higher the previous year. Fruit production was greater on the stub-pruned trees for the second year in a row. The Hi-Early Delicious variety yielded 1.7 more boxes per tree than did the trees pruned by the conventional method.

6. Pear juvenility. Distinct progeny differences were noted among seedlings in the pear breeding program indicating that there is a genetic basis for precocity of bloom.

7. Chemicals to retard blossoming, break dormancy, and control growth of peaches. At Byron, Ga., gibberellic acid sprays applied as a substitute for inadequate chilling gave longer shoot growth, increased flower size and elongated pedicels.

At Fresno, Calif., cytokinin treatment of five peach varieties slightly stimulated flower and leaf bud development when treating was done near the end of the rest period but not earlier.

8. Cold temperature effects on peach trees. At Experiment, Ga., natural exposure to freezing, five days subsequent to 80°F weather and two days before full bloom severely damaged half of the 1-year-old trees in a 'Loring' block and 2-and-3-year-old trees primarily in other orchards. Late September application of N and fluctuating temperatures in bioclimatic chambers each delayed blossoming six to ten days.

At Byron, Ga., damage to feeder roots of trees, subjected to 15° and 0°F degrees artificially was not different in soil of high and low Pythium count. Tissue browning in trees injected with bacterial canker toxin and frozen proceeded as far as the toxin was translocated and was less extensive in unfrozen tissue.

9. P.L: 480 Research. Research in Poland on the role of natural growth regulators in shootgrowth, bud dormancy, and flower initiation of fruit trees has shown that abscissic acid, phlorotic acid, and phloridzin are natural components of apple leaves. All three compounds are believed to regulate growth and dormancy and their identification is significant.

C. Variety Evaluation

1. Apples. Major commercial varieties are not suited to production in the southeastern states. Disease problems are more abundant in this area with fire blight being particularly destructive.

2. Peach and nectarine. At Fresno, Calif., 'Springold' was promising but 'Delight', 'Lateglo', 'Sunset', 'Summertime' and 'Gene Elberta' were not. 'Lexington' nectarine was too small, too dark and had soft sutures.

At Fort Valley-Byron, Ga., and at Beltsville, Md., 'Ranger' set heavier crops than other varieties under unfavorable weather and frosty conditions.

3. Plums. At Fresno, Calif., 'Ozark Premier' lacked attractive blush and ground color while 'Premier' cracked excessively.

4. Apricots. At Byron, Ga., the Fresno plum introduction Frontier is well adapted.

RPA 205 - CONTROL OF DISEASES

1. Apple

Apple scab (Venturia inaequalis). Cooperative research continues at Purdue University, Lafayette, Ind., on the nature of disease resistance. Fungitoxic oxidation products were isolated in biochemical studies of the host tissue at the site of infection. Chloramphenicol delays the expression of the hypersensitive reaction of the host until protein synthesis starts to return to normal. This may implicate protein synthesis in the mechanism of disease resistance.

Powdery mildew (Podosphaera leucotricha). At Hood River, Ore., lime-sulfur sprays controlled powdery mildew in Newtown apples better than Karathane which is the standard fungicidal control. Temperatures above 90°F, however, cause severe injury to foliage and fruit. Indolebutyric acid applied in lanolin to the cut surface of apple trees infected with powdery mildew caused extremely heavy ascocarp development. Cleistothecia did not develop, however, when the same treatments were applied to apple leaves.

Apple latent virus-1. At Wenatchee, Wash., the apple latent virus-1 was found to cause symptoms in certain Prunus species and to be symptomless in others. The virus could not be detected by indexing with four woody indicator species but back indexing with herbaceous indicator plants showed the virus to be present.

Wood-rot fungus (Polyporus versicolor). A destructive heart-rot disease of apple was observed near Hood River, Ore. The causal fungus has been identified as Polyporus versicolor but control measures have so far been unsuccessful.

2. Pear

Fire blight (Erwinia amylovora). At Beltsville, Md., over 11,000 pear seedlings from controlled crosses are being evaluated. Inoculation studies for resistance to fire blight show that there is extreme variation in susceptibility between progenies. A sand-blast method of inoculation proved satisfactory under conditions of high humidity and cool temperatures.

In a study of fire blight cankers, eight different types of Erwinia amylovora isolates were detected during the fall and winter months. Not all bacterial types were found to be pathogenic. In a greenhouse test, streptomycin sprays were found to be ineffective in controlling fire blight if the sprays were applied 6 hours or longer following artificial inoculation. Without injury to the plant, streptomycin sprays were effective up to two days.

Stony pit virus. At Wenatchee, Wash., an isolate of the stony pit virus caused disease symptoms in six commercial varieties of pear.

Pseudomonas blight (Pseudomonas syringae). Blossom infection was particularly bad at Beltsville, Md. The Magness variety was particularly susceptible. The high incidence of infected blossoms seriously reduced fruit set in susceptible varieties.

Storage rot. At Hood River, Ore., preharvest sprays of Ziram significantly reduced the storage rot problem in the Anjou winter pear.

3. Peach

Bacterial leaf spot (Xanthomonas pruni). At Beltsville, Md., the addition of dimethyl sulfoxide (DMSO) to Terramycin sprays on peaches significantly enhanced control of peach bacterial spot caused by X. pruni. Using radio-labelled DMSO, excessive residue was found to persist on mature peach fruit as late as four weeks after application. Research for 2 years in a grower orchard has resulted in a temporary permit for use of oxytetracycline for bacterial spot control on peach. High-titre preparations of bacterial spot phage were obtained and maintained for 8 weeks; the preparation remained infective for 3 weeks in peach leaves and spread slightly in the tree.

At Clemson, S.C., stomatal differences between varieties did not correlate with resistance to bacterial spot. Stomates open in the dark when high humidity favors infection. At Durham and Raleigh, N.C., leaf extracts inhibitory to X. pruni have been separated and partially characterized.

Bacterial canker. At Clemson, S.C., early pruning predisposed peach trees to injury by bacterial canker organisms applied either at time of pruning or at bloom time. This was true even when low temperatures were not encountered. Inoculation with the organism of early-pruned trees at bloom time caused greatest injury.

Brown rot. At Clemson, S.C., three preharvest applications of the methyl ester of 1-butylcarbamoyl)-2-benzimidazole carbamic acid and surfactant gave fungistatic control and prevented conidial formation while aureofungin at three rates was ineffective.

Root and crown rots. At Beltsville, Md., five Pythium spp. caused pre-emergence damping-off of peach seedlings but none attacked 2-month-old seedlings. However, two Phytophthora species were pathogenic to 2-month-old

seedlings. A new peach disorder, widespread in Mid-Atlantic orchards, is being studied.

At Athens, Ga., temperature interrelations with pathogenicity of Pythium species is continuing. Rootstocks are being screened for resistance to Pythium and nematodes. Fumigants (Fumazone and Dexon) appear to be reducing tree losses and increasing yields.

At Berkeley, Calif., 11 isolates of Clitocybe spp. from peach growing regions gave optimum growth at 27-30°C and produced rhizomorphs on selective extracts.

Virus diseases. At Logan, Utah, no interference of peach mosaic and asteroid spot was evident in symptomless hosts. 'Bonanza', a dwarf variety, is a good x-disease virus index plant.

4. Plums

X-disease. At Wenatchee, Wash., an X-disease virus strain produced severe symptoms on 3 varieties, moderate on 3, and mild on 1 variety. Several clones and native species were symptomless carriers and 3 cultivars were resistant.

Miscellaneous viruses. At Davis, Calif., a virus-like pathogen was transmitted from plum trees with rusty blotch to herbaceous plants.

5. Apricots

Ring-pox virus. At Logan, Utah, natural spread of the virus to adjacent trees was noted. At Davis, Calif., 'Royal' is more sensitive to virus infection than other commercial varieties.

6. Cherries

X-disease virus. At Logan, Utah, sweet cherries on mahaleb rootstock lost resistance when inoculum was abundant and 'Duke Braune Blankenburger' as an interstock was ineffective.

7. General stone fruits

Miscellaneous viruses. At Wenatchee, Wash., a graft-transmissible disorder causing greenness of petal veins and other blossom anomalies was described. 'Elberta' and seedlings of four Prunus spp. were shown to be symptomless carriers of spur cherry virus.

Plant extracts with animal tumor inhibitors inhibited infection of two plant viruses and suppressed virus synthesis. Two phytoalkaloids were not effective against plant viruses but extracts from source plants inhibited synthesis of plant viruses.

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SMALL FRUIT BREEDING AND GENETICS, DISEASES,
VARIETY EVALUATION, PHYSIOLOGY AND CULTURE

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968		Total
	Research	Problem Area	
	<u>304</u>	<u>205</u>	
	:	:	:
Maryland (Beltsville)	2.1	1.1	3.2
California	1.5	1.0	2.5
Illinois	2.3	0.7	3.0
New Jersey	-	1.0	1.0
North Carolina	-	-	-
Oregon	1.2	0.9	2.1
Wyoming	0.2	-	0.2
Total	7.3	4.7	12.0

Intramural program is supplemented by extramural support representing (a) 1.0 SMY's at State Agricultural Experiment Stations 1/, (b) 0.3 SMY's at other U.S. Institutions 2/, and (c) P.L. 480 funds in 2 countries representing 39,978 U.S. dollars equivalent.

1/ RPA 304 0.3; RPA 205 0.7

2/ RPA 205 0.3

Problems and Objectives

Present varieties of small fruits and grapes lack broad regional adaptation suitable for modern commercial use. Needs include large (for ease of picking), firm-fruited (for marketing), disease-resistant varieties for freezing and for long distance or local consumption, with a sequence of ripening throughout the season. Causal agents of disorders must be identified, and methods developed for effective and economical control of important fungus, nematode, and virus diseases of berries and grapes. Existing information on environmental factors limiting production is inadequate. The effect of temperature, soil moisture, diseases, and nutrition on plant growth, hardiness, and productivity needs study. Investigations are needed for cultural practices in propagation and plantation management that will result in high production of good quality fruit and reduced production costs.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Originating berries and grapes with improved horticultural plant or vine, and fruit qualities.
2. Originating grape rootstocks that are pest resistant and adapted to fruit area soils and climates.
3. Determining etiology and economic control of grape and berry diseases, particularly viruses.
4. Developing plantation or vineyard management systems to improve berry and grape yields and quality, and to reduce costs.

Progress - USDA and Cooperative Program

-- Small Fruits --

RPA 30⁴ - Improvement of Biological Efficiency

A. Breeding and genetics

1. Grape

American bunch grapes

The two most promising sources of resistance to black-rot fungus are from a Vitis riparia clone from Maryland and a V. rupestris from Illinois which both gave nearly 50% immune seedlings. Black rot is the most prevalent and serious fungus disease of bunch grapes in the eastern United States. Consistent differences exist among varieties and wild American species of grapes in their susceptibility to this disease.

Muscadine grapes

Three new perfect-flowered varieties of muscadines were released at Meridian, Miss. Chief is a dark variety whose fruit does not shatter when ripe. Bountiful is a glossy, purple-fruited variety somewhat larger than Creek with a rich vinous flavor. It ripens about mid September at Meridian. Southland has non-glossy, purple fruit about the same size as Hunt with very good flavor. It is a midseason variety.

The three varieties are the culmination of the Department's effort to originate self-fruitful muscadines. High-quality, perfect-flowered (self-fruitful) varieties are rare and the new varieties eliminate the need for pollinating male vines and also serve to pollinate existing quality female varieties.

2. Strawberry

The red-stele root-rot resistant variety Redchief was released in 1967, jointly with the Maryland Agricultural Experiment Station. Redchief is a midseason variety for areas where red stele is a problem and where Sure-crop is unproductive. New selections were made from 70,000 first test seedlings grown at Corvallis, Carbondale, Willard, and Beltsville, many of which are resistant to red stele root rot.

At Cheyenne, Wyo., winter-hardiness has been retained in a high percentage of strawberry seedlings in tests for the Great Plains area. Three winter-hardy selections appear promising as potential varieties in advanced tests.

3. Raspberry

The NC 223 red raspberry is deemed worthy of introduction for the south-central U. S. At Corvallis, Ore., 61 selections appear promising for mechanical harvesting. US-Oreg 131⁴ is equal in quality to Willamette when canned. US-Oreg 1⁴10 is equal in quality to Sumner in frozen pack.

At Cheyenne, inheritance of the summer-fruited character in raspberry appears to be recessive.

4. Blackberry

Thornless varieties and selections have been originated that are winter-hardy and productive. A dominant thornless character has been derived by breeding. Diploid seedlings from a cross of Burbank Thornless (2X) x Early Harvest (2X) were all partially to completely sterile.

5. Blueberry

An early-ripening blueberry variety, Bluetta, was released in 1967, jointly with the New Jersey Agricultural Experiment Station. Bluetta ripens very early, is consistently productive, and has better flavor than the variety Weymouth which is the current standard for the very early season. Three highbush selections are potential varieties in North Carolina and three rabbiteyes are promising in Georgia.

In genetic studies at Beltsville, tetraploid blueberries behave like diploids in meiosis except $4X$ Vaccinium atrococcum (derived from $2X$ V. atrococcum by colchicine) which is irregular. Inbreeding reduced fertility of seedlings.

B. Culture and Physiology

1. Grape propagation. At Fresno, Calif., grafting grapes in mid November was a better period than later grafting. Bench grafts planted early had higher survival than later plantings. Mounding soil over newly set grafted canes was superior to coating grafts with asphalt.

2. Blueberry pollination. At Beltsville, Md., and in New Jersey, seed content of fruits was less for Coville than for Bluecrop. Seed content was directly related to quantity of pollen applied to stigmas.

RPA 205 - Control of Diseases

1. Grape

Virus diseases. In California White Emperor Disease is leaf roll virus and not corky bark. The 1613 rootstock is highly resistant or immune to the vector of fan leaf virus. Fleck condition of leaves is incited by a new virus that is not soil retained. Intergrafts of grape and stone fruit virus indicators suggests a relationship between grape fan leaf and sour cherry yellows.

2. Strawberry

Virus diseases. Even though the Northwest strawberry variety is virus tolerant, virus-free plants produced 50% more runners than plants infected with individual and complexes of viruses. Of 29 strawberry fields in Oregon sampled for viruses, 27 fields had infected plants. Necrotic shock virus occurred in half the fields and has previously never been detected outside of California. At Beltsville, Md., efforts to free plants from virus diseases by culturing stem tips 2 to 5 mm long was partially successful. Attempts to culture tips 1 mm or less in length gave low survival.

Fungus leaf spot diseases. Strawberry varieties differed in their reactions to 37 different leaf spot disease isolates. Eight varieties were selected as differentials for further leaf spot research.

Fungus root rot diseases. Black-root infected strawberry plants have yielded 65 fungi many of which are parasitic. Fusarium, Pythium and Rhizoctonia occur most frequently in the black-root complex.

3. Raspberry and Blackberry

Five of seven Munger variety black raspberry stocks were found to be infected with an unknown virus. Phytophthora erythroseptica was found for the first time to be parasitic on the roots of red raspberry plants in the western United States.

4. Blueberry

Red ringspot virus continues to spread in New Jersey, but not in Michigan. The vector is unknown. Zineb is equally effective for cranberry rot control regardless of application rates from 100 to 250 gal/A. Tolerance of blueberry varieties to cane canker is being evaluated using 10 month old seedlings.

Publications - USDA and Cooperative Program

-- Small Fruit and Grape --

RPA 30⁴ - Improvement of Biological Efficiency

Breeding and Genetics

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RPA 205 - Control of Diseases

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CITRUS AND SUBTROPICAL FRUIT BREEDING AND GENETICS,
DISEASES, VARIETY EVALUATION, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968			Total
	Research	Problem	Area	
	<u>304</u>		<u>205</u>	
<u>Citrus</u>				
California	: 2.7		: 0.6	: 3.3
Florida	: 6.9		: 4.1	: 11.0
Texas	: 2.8		: -	: 2.8
Total citrus	: 12.4		: 4.7	: 17.1
<u>Dates and other subtropical fruits</u>				
California	: 0.7		: 0.2	: 0.9
Total dates	: 0.7		: 0.2	: 0.9
Total	: 13.1		: 4.9	: 18.0

Intramural program is supplemented by extramural support representing (a) no SMY's at State Agricultural Experiment Stations, (b) no SMY's at other U. S. institutions, and (c) P.L. 480 funds in 3 countries representing 82,580 dollars equivalent.

Problems and Objectives

Citrus is the most popular fruit in the United States. Its production exceeds the combined production of the six major deciduous tree fruits. No disease or soil condition is as devastating to the citrus industry as is a major freeze. Precise information is lacking about the interrelation between climatic factors and growth, cold hardiness and production; on the absorption processes and functions of various elements needed in growth and the effects of soil salinity, alkalinity and high water retention on growth; on the biochemistry of citrus metabolism and the effects of air pollutants on metabolism and growth; on various diseases and methods to control them. Currently used rootstocks do not induce enough cold hardiness in tops, are seriously affected by diseases and nematodes, are not tolerant enough to high soil alkalinity, salinity, and poor drainage and do not induce high enough yields of high quality fruit. Present scion varieties generally lack cold hardiness, disease resistance, fruit quality, widespread season of maturity, and are unsuitable for both fresh market and processing.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Originating scion kinds and varieties with improved horticultural tree and fruit qualities.
2. Originating rootstock kinds and varieties that tolerate pests, low temperatures, poor drainage, and salinity.
3. Determining etiology and economic control of diseases, particularly viruses.
4. Determining physiological nature of citrus dormancy, cold hardiness, heat tolerance, and salt tolerance.
5. Determining optimum nutrient levels in sandy citrus soils.

Progress - USDA and Cooperative Program

-- Citrus --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Orange.

Pollination studies. Temple, Orlando, and Lee are good pollinizer varieties for Robinson. These same varieties were effective for Page, but Lee appeared to be the most effective since it led to the largest Page fruits. Similar results were obtained for Page earlier and the specific effect from Lee

pollen is considered to be an example of metaxenia

2. General Citrus

Check List on Taxa in Citrus. To provide readily available information on species in Citrus, Fortunella, Poncirus, and other genera in the orange subfamily Aurantioideae, family Rutaceae, the Indio, Calif., and Orlando, Fla., stations have prepared a comprehensive check list of more than 1800 entries. The list will be a valuable tool for the taxonomist and breeder working in this group.

B. Physiology and Culture

Rootstocks. In a field trial in Texas, 4-year-old Marrs orange trees on 11 rootstocks bore the heaviest crops on C61-220 (Cleopatra X Troyer citrange F1), Changsha mandarin, citrumelo-4475, sour orange, and Morton citrange. Twelve-year-old old-line red grapefruit outyielded nucellar red grapefruit on 10 of 11 rootstocks with no difference in yield on one rootstock. Hurricane damage reduced the yield of these trees to 43% of the 1967 crop. Texas sour and Karna Khatta were the best of 11 rootstocks tried with California red grapefruit tops.

Frequent tree measurements and continuous yield records enable evaluation of rootstock merit in a much shorter period of time than usually deemed necessary to test new rootstocks. A number of new dwarfing stocks of merit have been found which may prove valuable in close-space citrus plantings.

In Florida tests, the Umatilla X Honey hybrid scion had very high total soluble solids and solid/acid ratios on all rootstock combinations. Orlando tangelo scion was the most prolific fruiter.

Morton citrange, when hand pollinated with Argentina trifoliate orange (for rootstock hybrid), produced 21.0 and 18.0 seed per fruit respectively as compared to 1.30 and 4.14 seed per fruit when open-pollinated.

Severinia buxifolia and Pomeroy trifoliate orange were found to be resistant to the citrus nematode, Tylenchulus semipenetrans.

Mineral Nutrition. Nitrogen need not be applied to the entire root system. Omitting N under the tree did not lower production over a 10-year period. Inoculation of four major viruses into nucellar Valencia trees on Rough lemon stock has not caused appreciable change in mineral composition of leaves for the first four years.

Salt tolerance. In pot culture experiments, grapefruit trees grew better in saline soil than Valencia orange trees. Trees under saline conditions contained higher levels of chloride and boron but not of sodium than the controls. Freeze injury to Valencia trees was not affected by saline treatment while Redblush trees in saline plots were injured more. Valencia

trees under saline treatment were able to harden under cool nights while Redblush trees were not. Saline treatment affected chloride in juice, Brix, and weight per fruit but did not affect rind color and thickness, juice/100 g fruit, % acid and Brix/acid ratio.

Cold hardiness. Three consecutive monthly freezes in Florida during the winter of 1966-1967 killed more two-year-old citrus trees on trifoliate orange rootstock than on Rough lemon rootstock. Trifoliate orange rootstock may not be able to maintain itself over consecutive monthly freezes because of its small root system and low vigor, in contrast to that of Rough lemon rootstock. When grown on Rough lemon rootstock the twigs of Red grapefruit apparently contain higher levels of nitrogen than when grown on Cleopatra mandarin or sour orange.

Seedlings of citrus types in Texas exposed to controlled hardening conditions hardened at different rates. The most hardy were kumquat and satsuma, followed by several other mandarins, oranges, grapefruit, and limes and lemons in that order. Hardening resulted in the accumulation of sugars in the leaves. Freezing was shown to inhibit photosynthesis and respiration of leaves and to injure cell membranes but had no effect on photoreduction enzymes, CO_2 fixation enzymes, or ATPase. GA_3 was shown to break bud dormancy at temperatures which would maintain dormancy and CCC and Abscisic II inhibited bud growth. Fiberglass and polyurethane tree banks were as effective as soil in protecting tree trunks from freezing.

Growth regulators. Ascorbic acid increased ethylene evolution from calamondin fruits and its effectiveness was increased by Cu or Fe. Ethylene is associated with abscission of citrus fruits and its evolution from mature fruit is increased by abscission-inducing chemicals. However, not all ethylene-producing chemicals are effective in increasing abscission. Ethrel (2 chloroethane phosphoric acid) was highly effective in inducing abscission of both fruit and leaves in the summer but not in the winter. Ascorbic acid, on the other hand, was effective both in the winter and summer in Florida. Ethrel applied to citrus trees at 51 degrees F. showed no abscission accelerating activity. Flushing of citrus is affected by both shoot and root temperature and by applied gibberellic acid. Regreening in Valencia oranges was associated with enhanced endogenous cytokinin activity and not with enhanced endogenous gibberellin. However, exogenous gibberellic acid increased regreening in Valencias and delayed chlorophyll destruction and carotenoids.

Climatology. In Florida, Pearl tangelo and Clementine mandarin reached peak fruit quality in mid-November under local conditions; Page orange, Orlando tangelo, Dancy and Fairchild mandarins in early December; Fortune mandarin in early February; and Valencia orange in late February.

One-year-old sour orange trees exposed to Florida climatic conditions made little shoot or root growth from December to March. No growth took place in a 60/40 degree chamber during this period. Root growth at 70/50 degrees was only half that at 95/85 degrees.

Moisture changes in leaves were influenced by diurnal light, air temperature, and relative humidity. A change in absorber thickness of leaves occurred during freezing.

In respiration studies with citrus plant tissues, root tips had the highest rates, next were disks from young leaves, then the last 5 cm of shoot tips and the old leaves had the lowest rates at 25 degrees C.

Citrus fruit and leaves may be heat hardened by short periods of exposure to high temperatures. Leaves may be injured at 120 degrees F. and fruit at 109 degrees F. The order of heat tolerance from most to least tolerant was for mandarins Cleopatra, Willow Leaf, Dancy, and Kinnow; for grapefruit Duncan, Marsh, Redblush, Foster, and Hudson.

RPA 205 - CONTROL OF DISEASES

Fungus diseases. Rating of the tolerance of citrus varieties to *P. parasitica* infections is based on differential growth rate between inoculated and non-inoculated plants rather than on the severity of disease symptoms such as size of lesion or degree of root rot. Australian sour (2-2-14) is still the most tolerant variety to *P. parasitica* infection in tests to date.

In California, 25 of 115 *Phytophthora* tolerant selections yielded progeny with fair to satisfactory tolerance to *P. parasitica*. Individual plants show persistently high tolerance to the fungus but their seedling progeny have about the same percent of survival as those from the original parent tree.

Virus diseases. Mechanical transmission of citrus viruses, especially exocortis, was emphasized. Properties of exocortis and factors affecting its spread by contaminated tools were defined. An unidentified citrus virus was found which can be mechanically transmitted between citrus and non-citrus hosts. The non-citrus host range for citrus variegation virus was greatly expanded.

Development of mottled-leaf symptoms in stubborn infected plants is most rapid at high temperatures. Fruit symptoms of stubborn disease were produced within eight months by grafting fruits to infected seedlings during the summer. In California and Arizona, stubborn disease field experiments with grapefruit and orange trees show that stubborn seriously affects growth and yield, the virus probably spreads in field plants, strains of stubborn virus exist, and some trees make an apparent recovery from the disease. Recommendations over the past 10 years for removal of stubborn-affected nursery and orchard trees have been of direct help to citrus growers in improving plantings.

PL 480 research in India reaffirms earlier conclusions that citrus dieback in India is caused by "greening disease" virus rather than tristeza as was first suspected but that dieback is enhanced by the interaction of the

greening virus and the fungus Colletotrichum gloedsporioides.

Diseases of undetermined cause. In tests with grapefruit in Florida, five pounds KCl (As K₂O) per tree applied annually from 1960 to 1968 produced typical Rio Grande gummosis symptoms as compared to none for the controls.

A disorder of grapefruit in Texas, commonly called "sheepnosing" because of a malformation of the fruit, is under investigation and appears to be non-pathogenic.

-- Date --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

Physiology and Culture

Date thinning. Low concentrations of 2,4-D and TD-692 were effective in thinning Medjool date fruit if applied two weeks after opening of the spathe. Thinning is effected by 2,4,5-T but fruit maturity is seriously delayed.

Date palms allowed to carry large bunches of fruit had smaller fruit and higher yields than those with small bunches but grades were not greatly affected by bunch size.

Publications - USDA and Cooperative Program

-- Citrus and Subtropical Fruits --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

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RPA 205 - Control of Diseases

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EDIBLE TREE NUT BREEDING AND GENETICS, DISEASES,
VARIETY EVALUATION, PHYSIOLOGY AND CULTURE

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968			Total
	Research	Problem	Area	
	<u>304</u>		<u>205</u>	
Maryland (Beltsville)	-		-	-
California	1.0		-	1.0
Georgia	1.0		1.0	2.0
Louisiana	1.8		1.2	3.0
Oregon	1.4		-	1.4
Texas	2.0		-	2.0
Total	7.2		2.2	9.4

Intramural program is supplemented by extramural support representing (a) 1.4 SMY's at State Agricultural Experiment Stations 1/, (b) 0.5 SMY's at other U.S. Institutions 2/, and (c) no P.L. 480 funds.

1/ RPA 304 1.2; RPA 205 0.2

2/ RPA 304 0.5

Problems and Objectives

Tree nut production in the United States is inadequate to meet the needs of the national consumption. Production of current varieties is not optimum and existing varieties are subject to diseases and frost damage to spring bloom. The nutritional requirements of nut trees are not completely known and the factors that induce biennial bearing are not understood. Diseases are often limiting factors and may even cause complete crop failure. Almonds are particularly subject to late frosts; later blooming varieties are feasible. Nut trees are known to have higher potassium requirements than the trees can absorb in heavy crop years but methods to increase absorption are not yet known. Current management research on tree spacing, dwarfing, rootstocks, and chemical fruit setters, as well as use of more productive varieties, have not yet achieved optimum total nut production.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Originating new nut varieties that are tasty, winter-hardy, late-blooming, pest resistant, and reliably productive.
2. Determining physiological nature and control of flowering, fruiting, and growth; emphasis is on overcoming biennial bearing.
3. Determining etiology and economic control of diseases; emphasis is on pecan scab.
4. Developing orchard management systems to improve fruit yield and quality and reduce costs.

Progress - USDA and Cooperative Program

-- Tree Nuts --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Pecan

Two new pecan varieties, Caddo and Shawnee, were released in March 1968 at Brownwood, Texas.

Caddo is precocious in fruiting and tends to bear regular crops of high quality nuts, particularly suited for commercial shelling. Shawnee is precocious in fruiting, prolific in bearing and produces well filled, high quality nuts. The nuts are of a good type for commercial shelling yet are very acceptable for the in-shell trade. Because of its precocity, it is well suited for close planting and should respond well to pruning designed to regulate production and hold the tree to desired size.

2. Almond

The new almond variety, Vesta was released in April 1968 at Fresno, Calif. Vesta consistently produces better kernel quality than other varieties currently used to pollinate Nonpareil, the principal commercial variety now grown in California. The quality of the kernel of Vesta is equal to or better than that of Nonpareil. Vesta appears to be more productive than commercially standard Nonpareil.

Almonds that show resistance to mites have been selected. Hybrids of nematode-resistant peach with almond are promising as almond rootstocks.

B. Physiology and Culture

1. Pecan

Propagation. At Shreveport, La., winter-grown pecan seedlings from fall-harvested seed could be bark-grafted onto cut-back nursery trees. The March 30 date of grafting gave a high take and the method was still partially successful until late July. Vegetative propagation of pecan trees with juvenile root pieces is a promising method of producing clonal rootstocks.

Soil management. At Shreveport, La., two weeks of flooding drastically reduced the number of fine roots and the amount of carbohydrate stored in the taproots. Native pecans grow on bottom lands near rivers and in some areas they are annually subjected to flooding. Prolonged flooding can be detrimental to growth.

Pruning. At Brownwood, Texas, pruning treatments to 19-year-old trees of three pecan varieties reduced yields by one-fourth to one-half as compared to non-pruned trees. However, income per acre from pruned trees was not reduced when compared to controls due to the increased nut quality and value of nuts per pound as a result of pruning. Alar treatments, alone or in combination with pruning treatments, resulted in increased set of poor quality nuts, and significant decrease in growth. All pruning treatments reduced the prevalence of "shuck disease". After two years observations one-fourth removal of the top per tree per year and heading back sides to prevent lateral tree spread appears to be the most promising treatment in regulating bearing, maintaining good nut quality, and maintaining adequate annual per acre yields of pecans.

Weed control. At Brownwood, Texas, Simazine and Bromocyl (Hyvar X) herbicides gave excellent season-long control of most weeds around six-year-old pecan trees. In areas where bromocyl accumulated as a result of transport in irrigation water, severe tree injury (chlorosis, defoliation and death of 3 trees) resulted. Diuron (Karmex) was the least selective herbicide used since it did not control certain annual weeds. Paraquat proved effective in spot treating for controlling perennial grasses like Johnson grass.

2. Filbert

Weed and sucker control. At recommended rates the herbicide dinitro generally was phytotoxic to young filbert leaves and stems. Histologic examination showed penetration and collapse of epidermal, cortical and phloem cells. Mature stems, one or more years old, possessed a suberized layer of cells and a periderm which resisted herbicide penetration. These results have led to the design of a herbicide combination of dinitro, diesel oil and water which will kill weeds and suckers, but not injure tree trunks, even in young orchards.

Propagation. Wood maturity has proved to be extremely important to successful propagation of filbert cuttings. Wood of terminal growth taken from mid-June to mid-July rooted best. Filbert cuttings are intolerant of poor aeration; they respond to bottom heat and rooting hormones and require mist propagation for survival in the bench.

Genetic differences are important in filbert grafting. Under identical environmental conditions, grafting success varied from 10 percent to 54 percent, depending on the stock/scion combination.

Filbert dormancy. Troublesome seed dormancy in the filbert requires several months of stratification to achieve satisfactory germination. Gibberellic acid treatment completely overcomes this dormancy, even in the Turkish filbert which normally takes two years to germinate. Plants 4" tall have been obtained two months after harvest.

Studies on filbert bud dormancy indicate that a minimum of 500 hours at 40°F is required for leafing out and that additional chilling up to 1,000 hours benefits vegetative growth.

Tree spacing. In the eighth year, filbert trees spaced 15' apart yielded as well as those spaced at 25'. This lack of competition is substantiated by height, width and trunk measurements which suggests that even higher tree populations may be possible and profitable in the early life of an orchard. Several hedgerow spacings have been established at Corvallis, Ore., to determine the best way to manage high density plantings.

Pollination, fertilization and blanks. Studies show that blanks are not associated with lack of pollination, because nonpollinated flowers abort. Even with pollination, about 80 percent of all flowers abort. Growth regulators are being tried to retain this bloom. Of the 20 percent of flowers which make the crop, irregular embryo and endosperm development has been observed histologically. This suggests improper double fertilization as one possible cause for blanks.

RPA 205 - CONTROL OF DISEASES

1. Pecan

Scab. Fungicide rates as low as 2.5 lbs of Dodine (Cyprex) and 1 lb of DUTER (Triphenyl Tin Hydroxide) in 500 gals of water effectively controlled scab at Albany, Cordele and Fort Valley, Ga. This is about one-half the amount of pesticides recommended earlier. The results were verified in Louisiana.

Among available varieties at Shreveport, La., only Elliott and Gloria were free of the scab fungus. Curtis and Farley were mildly infected.

Foliage diseases. At Shreveport, La., Dodine more effectively reduced vein spot than DUTER. Dodine (Cyprex) at 1 lb of 65% wettable powder per 100 gallons of water reduced vein spot lesions to 39% and 27% that of unsprayed trees of Success and Stuart varieties respectively; whereas, DUTER, at 0.2 lbs of 50% wettable powder per 100 gals of water, reduced vein spot lesion to 61% and 58% of unsprayed trees of Success and Stuart variety, respectfully.

Shuck disease. At Shreveport, shuck disease was attributed to adverse environmental conditions. Although shuck disease appears to be associated with the fungus disease vein spot, its cause is attributed to a complex of adverse conditions such as excess rainfall, heavy soils with poor aeration, excessively large crops, tree crowding, and defoliation by leaf diseases or insects.

Publications - USDA and Cooperative Programs

-- Edible Tree Nuts --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

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POTATO BREEDING AND GENETICS, DISEASES,
CULTURE, AND VARIETY EVALUATION

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968					Total	
	Research Problem Area						
	304	205	204	402			
Potato	:	:	:	:	:		
Maryland (Beltsville)	: 1.3	: 1.4	: 0.4	: 1.1	: 4.2		
Colorado	: ---	: ---	: ---	: ---	: ---		
Idaho	: ---	: 0.4	: ---	: 0.6	: 1.0		
Maine	: 0.3	: 0.7	: ---	: ---	: 1.0		
New Jersey	: ---	: ---	: ---	: ---	: ---		
New York	: ---	: ---	: ---	: ---	: ---		
Texas	: 0.1	: ---	: ---	: ---	: 0.1		
Washington	: ---	: 1.0	: ---	: ---	: 1.0		
West Virginia	: ---	: ---	: ---	: ---	: ---		
Wisconsin	: 1.0	: ---	: ---	: ---	: 1.0		
Total	: 2.7	: 3.5	: 0.4	: 1.7	: 8.3		

Intramural program is supplemented by extramural support representing (a) 0.5 SMY's at Iowa State Agricultural Experiment Station,^{1/} and (b) P.L. 480 funds in 2 countries representing \$129,428 U.S. dollars equivalent.

^{1/} RPA 204 0.5

Problems and Objectives

The potato is grown in every State and it is planted or harvested every month of the year. Yield, culinary, and processing qualities vary greatly because of extreme environmental differences among the many production areas. Approximately 35% of the tablestock crop is now converted into over 50 processed products. Because of this increase in potato processing, there is a demand for suitable varieties that will satisfy the quality factors inherent in processing these new products. It is also important to understand the nature of disease and insect resistance and the methods to control disease agents in order to reduce crop loss and to decrease, or eliminate, the need for chemical control.

Major objectives of the research are to develop high-quality, better adapted, disease-resistant potatoes for tablestock and for processing. These objectives are achieved by:

1. Selecting high-quality lines that will also produce high yields through standard and new breeding methods and also using interspecific hybridization.
2. Studying and employing genetic control of enzymatic systems to synthesize new varieties for processing.
3. Selecting lines with multiple resistance to major potato diseases and insect infestation through standard and newly devised test procedures.
4. Studying the nature of disease resistance through definitive studies on viruses, fungi, and bacteria, and through studies of physiological disorders.
5. Conducting varietal evaluation trials.

Progress - USDA and Cooperative Program

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF FRUIT AND VEGETABLE CROPS

A. Potato Breeding and Genetics

1. Potato introductions. In cooperation with the New Crops Research Branch, 56 new stocks were received in 1967 from 12 foreign countries. Seed samples of 145 introductions were sent to the National Seed Storage Laboratory, Fort Collins, Colorado. Shipments to 16 States and 21 countries included 1,966 and 864 tuber samples of species introductions, and 204 seed and 477 tuber samples of germ plasm involving introductions developed cooperatively by USDA and Wisconsin. Also, 368 herbarium specimens, representing 92 species introductions, were prepared from field-grown seedling populations. Seedling families of 92 interspecific crosses between frost-resistant and frost-susceptible species were evaluated for tolerance to a sequence of 27-, 30-, and 27-degree overnight lows.

2. Potato cytogenetics. The effects of inbreeding in diploids of S_0 , S_1 , and S_2 families grown from true seed at Sturgeon Bay, Wisconsin, showed loss of vigor in plant height and tuber production following inbreeding. Diploid selections from *S. tuberosum* matings were doubled vegetatively to provide parental stock for producing comparable diploid and tetraploid hybrids. When the two ploidy levels were compared on a per stem basis, the tetraploids were superior in yield, leaf area, and in tuber production per unit of leaf area. In the study of aneuploids and their diploid sibs, pollen stainability of the aneuploids ranged from 35-75% while seed/fruit set averaged from 25-100%. Transmission of the extra chromosome through the female in 5 crosses involving trisomics was 20-25%. Chromosome counts indicate increased haploid frequencies after treatment with colchicine of pollen from *S. phureja* and *S. tarijense* pollinators.

3. New variety releases. "Alamo" was released cooperatively with the Agricultural Experiment Station of Texas. It is a medium-early maturing variety with white, smooth tubers. Its high-yielding ability, combined with resistance to the diseases of late blight, common scab, net necrosis, and mild mosaic, should prove valuable to growers who want an early variety suitable for the fresh market and heat-processed products.

"Lenape" was released cooperatively with the Pennsylvania Agricultural Experiment Station. "Lenape," with its high solids content, excellent chipping qualities, and low sugar content should be valuable to growers and processors of potatoes for chips. It is medium in maturity and is resistant to late blight, mild mosaic, net necrosis, and stem-end browning.

"Wauseon" was released cooperatively with the New York Agricultural Experiment Station. "Wauseon," with its resistance to the golden nematode, low translucency of processed potato dice, and its acceptable chipping ability, should be of value to growers who have problems with any of these factors. It also has moderate resistance to common scab, resistance to latent and mild mosaic, and to tuber necrosis from leafroll infection.

B. Varietal Development

1. Varieties for the South. Over 150 advance selections and standard varieties were grown in Alabama, Florida, Louisiana, Maryland, Mississippi, South Carolina, Texas, and Virginia. Seedling B5132-3 was outstanding in most of these States. It is noted for its resistance to scab, *Verticillium* wilt, and mild mosaic, and for its yielding ability, tuber appearance, and chipping quality.

2. Varieties for the West. In Colorado 498 selections were made from 60,000 seedlings grown for the first time in 1967. An additional 103 seedlings, previously selected, were increased. "Wauseon" was superior to most selections in yield (472 cwt./acre) and chip qualities, and "Lenape" was superior in dry-matter content and chip quality.

In Idaho 6 advance seedlings and 4 varieties were compared with Russet Burbank at 2 locations for yield, specific gravity, resistance to Verticillium wilt, and for sugar content. Seedlings A589-65 and A6135-4 were above average in both locations for yielding ability, for resistance to Verticillium wilt, and for high specific gravity; but they were too high in reducing sugar, especially after storage for 3 weeks at 40° F.

In Washington only 17 out of 35,000 seedlings grown in 1967 were selected for increase and evaluation. "Lenape," 48-1, and B5415-6 yielded 694, 747, and 718 cwt. per acre, respectively, compared with 275 cwt. per acre for Russet Burbank. All three selections were superior to Russet Burbank in chip color. "Lenape" made good chips when stored at low temperatures from 42 to 68 days.

"Oromonte" was released cooperatively with the Colorado Agricultural Experiment Station. "Oromonte" is a late-maturing, yellow-fleshed chipping variety which produces well in Colorado. It has resistance to virus Y and to internal discoloration caused by Fusarium oxysporum f. tuberosi. It is more resistant to storage diseases and mechanical injury than the variety Kennebec.

3. Outstanding seedlings. Seedling B6024-3 is being increased because of its russet skin, fine tuber appearance, medium to early maturity, chipping qualities, and for its resistance to scab, net necrosis, stem-end browning, and mild and rugose mosaics. In 1967 in Maine it yielded 429 cwt. per acre compared to 397 cwt. for Irish Cobbler. Seedling B6039-1 is a medium-late maturing variety with fine-appearing white tubers. It is similar to Chippewa in yield when grown in Maine. It has good chipping qualities and has shown resistance to scab, net necrosis, stem-end browning, and to latent, mild, and rugose mosaics. It has shown a high level of field resistance to the late blight race 1,2,3,4 in Maine and to both early blight and races of late blight in Northern Nigeria. Seedling B6111-18 is an early-maturing seedling with smooth white tubers that chip well. It has a high level of resistance to scab, leafroll, net necrosis, stem-end browning, late blight, and mild and rugose mosaics.

RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

A. Breeding for Disease Resistance

1. Nematode resistance. Seventeen newer seedlings were tested and 8 older selections were retested for resistance to the golden nematode (Heterodera rostochiensis) in cooperation with the New York Agricultural Experiment Station. Also 12 advance selections were retested for resistance in cooperation with the Golden Nematode Laboratory, Sidney, B.C., Canada. Two seedlings, B5287-5 and B5459-7, when inoculated with this nematode, showed no new cysts compared to 1,408 for Russet Burbank at the end of the growing season. Seedlings B6111-18, B6377-10, and B6377-12 showed a high

degree of tolerance or resistance to the root knot nematode (Meloidogyne spp.) and to brown rot (Pseudomonas solanacearum) in cooperative tests with AID at Ta-Hoss, Nigeria.

2. Early blight resistance. Over 400 advance seedlings and varieties were screened for resistance to Alternaria solani at Beltsville. Differences in susceptibility were observed. Of 173 selections sent to Nigeria for screening for resistance to early blight, 33 promising selections were saved for replanting. Eight seedlings were highly resistant to both early and late blight. Seedlings B6092-2 and B6097-9 had less than 1% foliage infection from both diseases.

3. Brown rot resistance. More than 400 advance seedlings and varieties were tested for resistance to Pseudomonas solanacearum at Beltsville. Marked differences in resistance and susceptibility, degree of resistance, as well as rapidity of decline in susceptible seedlings were noted.

4. Multiple disease resistance. In Maine, 58 advance selections were tested for resistance to 10 potato diseases: ring rot, scab, Verticillium wilt, leafroll, net necrosis, stem-end browning, viruses X, A, and Y, and late blight. Seedlings B6111-18 and B6138-3 showed resistance to 7 of the diseases. Thirty-two of the 58 selections had multiple resistance to 5 or more of the 10 diseases in the tests.

5. Multigenic field resistance to late blight. In cooperation with West Virginia University, tests for field resistance to late blight were conducted in Maine and West Virginia. Over 450 selections were screened with Race 1,2,3,4 in the field at both locations. Many selections had a high level of field resistance. Seedling B6038-1 has field resistance to blight combined with resistance to scab, Verticillium wilt, net necrosis, stem-end browning, and mild mosaic.

6. Resistance to Rhizoctonia (stem canker). Five varieties were evaluated in replicated field plots for resistance to Rhizoctonia solani. Significant differences occurred between Katahdin (Index 1.54) and 41956 (Index 9.69).

B. Virus Diseases

1. Characterization of virus diseases. Infectious entities from potato spindle tuber virus-infected plant tissue have properties that differ from those of conventional virus particles. Results of different tests suggest that the extractable infectious agent in potato spindle tuber virus may be a double-stranded RNA.

2. Production of virus-free stock (PL 480, Spain). At Vitoria, Spain, a Green Mountain plant appears to be negative for presence of virus X. At present, growing meristem tissue on agar cultures offers the best solution for freeing potato tissue of virus X.

RPA 204 - CONTROL OF INSECT PESTS OF FRUIT AND VEGETABLE CROPS

A. Insect Control and Host Relations

1. Insect resistance. The reaction of 45 seedlings and varieties to the potato leafhopper (Empoasca fabae) and the potato fleabeetle (Epitrix cucumeris) were compared in Ohio on treated (Thimet) and untreated soil. The untreated plots yielded only 36% as much as the treated plots did in 1967. Comparing the same clones, this percentage was 49 in 1966. Data showed that the leafhopper can reduce yield even though the foliage is unchanged by hopperburn injury.
2. Potato leafhopper-host relations (Grant - Iowa). In cooperation with Iowa State University and the Division of Entomology, the metabolic utilization of valine and isoleucine enhanced survival of early-instar nymphs of potato leafhopper (Empoasca fabae). A method for validating acceptability of plants for oviposition by E. fabae is practicable and may be acceptable to plant breeders in evaluating specific insect-response to potato plants.

RPA 402 - PRODUCTION OF FRUIT AND VEGETABLE CROPS WITH
IMPROVED CONSUMER ACCEPTABILITYA. Quality Evaluation of Seedlings and Varieties

1. Seedling evaluation. In Maine, 170 seedlings out of 1,398 seedlings grown in 12-hill rows were evaluated. Specific gravity readings ranged from 1.056 to 1.102. Chip color varied from 5.2 (acceptable) to 10.0 (very dark). Ninety seedlings and varieties and 126 advance selections were compared. Yields varied from 524 cwt. of U.S. No. 1 tubers per acre to 168 cwt. Specific gravity readings ranged from 1.096 to 1.055. Chip color varied from 6.7 (acceptable) to 10.0 (very dark). Seedling BR5948-1, from a cross between B3556-12 and "Lenape," is a good example of a seedling possessing disease resistance combined with processing qualities. Its yield of 320 cwt. per acre of tubers, with a specific gravity rating of 1.086 and acceptable chipping qualities, plus medium-early maturity, are good. In addition, it has immunity to viruses X and A plus a high level of resistance to leafroll, scab, and the common races of late blight.
2. Varietal and selected seedling evaluation. In cooperation with Campbell Soup Company, 10 varieties and 15 seedlings were grown in Maine, New Jersey, Ohio, Pennsylvania, and Wisconsin. This material, plus 351 additional selections grown in Maine, were evaluated for yield, specific gravity, french frying, mashing, sloughing, and translucency before and after storage at various temperatures. "Wauseon" again rated well in translucency and sloughing in all locations. Seedling B5461-4 was exceptionally good when grown in Maine, and B5421-3 also rated high but was lacking in tuber appearance and yield at two locations. B6097-9 and B6138-3 grown in Maine were rated superior in evaluation for french fries. "Lenape" and B5042-2 grown in New Jersey were rated highest in the mashed-potato evaluation test.

Additional trials in Texas show that "Wauseon," "Alamo," "Lenape," and B 5096-11 have yielded as well or better than the standard variety.

Publications - USDA and Cooperative Program

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY
OF FRUIT AND VEGETABLE CROPS

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RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

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RPA 402 - PRODUCTION OF FRUIT AND VEGETABLE CROPS WITH
IMPROVED CONSUMER ACCEPTABILITY

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SWEETPOTATO BREEDING, GENETICS, VARIETAL EVALUATION, AND DISEASES
Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968						
	Research Problem Area						
	304	:	205	:	402	:	Total
Maryland (Beltsville)	:	0.5	:	0.5	:	---	1.0
Georgia	:	0.6	:	0.2	:	0.2	1.0
Total	:	1.1	:	0.7	:	0.2	2.0

Problems and Objectives

The total production, acreages, and the per capita consumption of sweetpotatoes have been declining for many years and are now at the lowest levels in over a half century. Costs of sweetpotatoes to the consumer remain high and these costs need to be reduced if use of the crop is to be increased. Further reductions in the high-labor requirements involved in producing, harvesting, and handling must be achieved through maximum use of mechanization. New, high-quality, disease-resistant, productive varieties suited to mechanized methods must be developed as well as equipment better adapted to handle the crop. Means must also be found to reduce losses caused by diseases, such as russet crack which is currently making the growing of some varieties impossible in certain production areas.

Major objectives of the research are to breed high-quality, better adapted, disease-resistant sweetpotatoes for fresh market and processing by:

1. Quantitative and qualitative genetic studies to improve breeding procedures.
2. Cytogenetic studies of other Ipomoea species to discern their relationship to I. batatas.
3. Obtaining interspecific crosses to help explain the origin of sweetpotatoes.
4. Evaluating advanced seedling selections for yield and processing qualities.
5. Developing techniques for disease control, principally by eliminating virus infections.

Progress - USDA and Cooperative Program

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF FRUIT AND VEGETABLE CROPS

A. Breeding and Genetics

1. Cytogenetic studies. There are now 365 accessions, representing some 95 species in the Ipomoea and related genera collection. Chromosome numbers of 42 species have been determined. A number of interspecific crosses have been obtained, and these crosses contribute to our knowledge of the possible origin of sweetpotatoes. Continuation of studies with Genome A Ipomoea species suggests that a wild tetraploid (I. tiliacea) has at least one genome in common with this group of plants. A new accession, I. gracilis, shows promise as one of the progenitors of the sweetpotato.

At Tifton, Georgia, quantitative genetic studies, directed toward the development of improved breeding procedures, have progressed according to plans. Seed of Cycles 2 through 7 of the random breeding test population are now available. A two-year parent-offspring study has been completed which will provide estimates of genetic components for use in prediction

of genetic advance under various breeding procedures. Four populations, in which different selection pressures have been controlled, are available to test the expected gains against those actually obtained. Recurrent selection for horticultural desirability was initiated in a randomly intercrossing population. The random-breeding population designed to have a wide and gradually expanding gene-source base has progressed through Cycle 3. Cycle 4 seedlings are now in the field. Seed of Cycle 3 population and the original random-breeding population have been submitted to the Seed Storage Laboratory, Fort Collins, Colorado.

2. Applied breeding. In 1966-67 and 1967-68, 30 parent clones (USDA and Maryland) were used in the Beltsville breeding program. About 25,000 seeds were obtained through controlled pollinations.

After screening for flesh colors, shape, set, and other horticultural characteristics, quality, enzymatic darkening reaction, storage, etc., 46 seedlings out of 9,500 produced in 1967 were selected for further tests in 1968.

Eleven of twenty-three 1966 "B" clones were found sufficiently productive and otherwise promising to warrant more comprehensive evaluation in 1968.

B. Seedling Evaluation

1. Testing advanced selections. B7537, a wilt- and black rot-resistant selection with low enzymatic darkening characteristics, gave higher yields of canner-size stock than the Centennial, Nemagold, and Porto Rico control varieties at Beltsville, Maryland. B7537 gave an acceptable canned product in processing tests. B7625 and B7633 were productive clones in field trials. Both clones possess good processing characteristics.

C-56-35 continued to show promise in Regional Trials of advanced lines, conducted in cooperation with 18 State Experiment Stations.

2. Enzymatic discoloration. Of the 1967 Beltsville seedlings retained at harvest and rated for enzymatic darkening potentials, 16 out of 54 had notably lower discoloration indexes than the Nemagold, Porto Rico, Goldrush, and Sunnyside controls.

RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

A. Diseases

1. Virus-disease transmission and control. Under greenhouse conditions the green peach aphid (Myzus persicae), and not the Abutilon whitefly, was implicated in the natural transmission of the russet crack virus. Positive control of russet crack by heat treatment was accomplished when the plants were grown in a compost soil of low conductivity during several months of treatment.

Publications - USDA and Cooperative ProgramRPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY
OF FRUIT AND VEGETABLE CROPSBreeding and Genetics

Jones, A. 1967. Should Nishiyama's Kl23 (Ipomoea trifida) be designated
I. batatas? Econ. Bot. 21: 163-166.

Jones, A. 1968. Chromosome numbers in Ipomoea and related genera.
Jour. Hered. 59(2): 99-102.

RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

Diseases

Bailey, W. A., and Hildebrand, E. M. 1968. New house stops development
of virus. Agricultural Research 16: 10.

ONION AND CARROT BREEDING, CYTOLOGY, AND GENETICS

Crops Research Division, ARS

(RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF FRUITS AND VEGETABLES)

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-years FY 1968
Maryland (Beltsville)	1.0
California	-
Colorado	-
Idaho	-
Texas	<u>0.1</u>
Total	1.1

Intramural program is supplemented by extramural support representing PL 480 funds in two countries representing 38,963 U.S. dollars equivalent annually. (Includes one PL 480 in RPA 402, U.S. dollar equivalent 10,004.)

Problems and Objectives

The production of carrots, onions and related crops is stabilized in specialized growing areas, with many varieties restricted in their range of adaptation and use. Susceptibility to disease and insect attack further limits the general suitability of some varieties. Genetic control of carrot male sterility for use in hybrid seed production has not been mastered, and there are other serious seed production problems in both onions and carrots. Research in the areas of pathology, physiology, genetics, cytology, and male sterility aid the public and private breeding programs on these crops.

Major objectives of the research are to

1. Improve quality, yield, disease- and insect-resistance.
2. Improve seed yields and efficiency of producing hybrid seed.
3. Develop basic information on genetics, cytogenetics, interspecific hybrids and male sterility in support of the breeding programs.

Progress - USDA and Cooperative Program

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Linkage testers in onions (Beltsville, Md.). Among 487 offspring of 51 independent trisomic ($2n + 1$) plants obtained from triploids, 94 plants were trisomic. The overall transmission rate of an extra chromosome was 19 percent and ranged from 0 to 80 percent in the various families.

Interchange chromosomes were transmitted to approximately half the progeny of reciprocal translocation heterozygotes, based on PMC meiosis analysis of 312 plants representing 17 independent exchanges produced by irradiation of seed.

2. Male sterility in plants. Tests to detect linkage between onion bulb color (dominant white vs. yellow) and male sterility showed these traits to segregate independently (Greeley, Colo., and Beltsville, Md.).

In research at Beltsville to create cytoplasmic male sterility by genome transfer into foreign cytoplasm, pollen fertility was studied in 40 radish x cabbage hybrids. Most were phenotypically male sterile or produced only aborted pollen, but a few had some stainable, normally-appearing pollen, up to 30 percent in one plant. No seed pods developed, either after backcrossing to cabbage or interpollination. An additional 35 hybrids treated with colchicine ranged from male sterile to 88 percent stainable pollen-producing, and 21 of them produced well-developed seed pods. However, only rarely did these pods contain seeds.

PL 480 grant, Israel. A correlation was found between chlorophyll variegation and cytoplasmic male sterility in peppers. Cytochemical tests indicate that in male-fertile petunia anthers callose accumulates in cell walls of microsporocytes from beginning of meiosis to tetrad-releasing-microspore stage, whereas in male-sterile sporocytes no callose was detected beyond early prophase. A corresponding difference in timing of callase enzyme activity was demonstrated.

B. Physiology and Culture. PL 480 grant, Israel. The electron diffraction pattern of carotene bodies isolated from carrot roots by centrifugation was practically identical to those of (1) carotene extracted by n-hexane and recrystallized by flash evaporation, and (2) crystalline carotene obtained from a commercial source. Highly purified preparations of isolated mature carotene bodies contained only 10-20 percent protein, being predominantly carotene and not interpretable as built solely of protein-carotene layers.

RPA 402 - IMPROVED CONSUMER ACCEPTABILITY

A. Physiology and Culture. PL 480 grant, Poland. From fertilizer experiments with carrots, some evidence was obtained that high nitrogen applications may increase the amount of greening in the roots, but no carry-over influence on callus-tissue culture was detected. The rate of chlorophyll formation in calluses is greater in alternating periods of darkness and light than in continuous light.

Publications - USDA and Cooperative Program

None.

BEAN AND PEA BREEDING, GENETICS, DISEASES, QUALITY, AND CULTURE

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968				Total	
	Research Problem Area					
	205	603	402	304		
<u>Beans, Snap</u>	:	:	:	:	:	
Maryland (Beltsville)	:	1.0	:	0.5	1.5	
Washington	:	0.4	:	0.1	0.8	
South Carolina	:	0.1	:	0.2	0.6	
	Total Snap Beans	:	1.5	0.3	1.1	
		:	:	:	2.9	
<u>Beans, Dry</u>	:	:	:	:	:	
Michigan	:	1.0	:	0.1	1.0	
Washington	:	0.4	:	0.1	0.8	
	Total Dry Beans	:	1.4	0.1	0.3	
		:	:	:	1.8	
<u>Beans, Lima</u>	:	:	:	:	:	
Maryland (Beltsville)	:	1.0	:	0.5	1.5	
South Carolina	:	0.1	:	0.1	0.2	
	Total Lima Beans	:	1.1	0.1	0.7	
		:	:	:	1.9	
<u>Cowpeas (Southern Peas)</u>	:	:	:	:	:	
Georgia	:	1.0	:	0.1	1.0	
		:	:	:	:	
<u>Lentils</u>	:	:	:	:	:	
Washington	:	0.4	:	0.1	0.5	
		:	:	:	:	
<u>Peas, Dry</u>	:	:	:	:	:	
Washington	:	0.4	:	0.1	0.5	
		:	:	:	:	
<u>Peas, Fresh</u>	:	:	:	:	:	
Oregon	:	1.0	:	0.1	1.0	
Washington	:	0.7	:	0.1	0.7	
	Total Fresh Peas	:	1.7	0.1	1.7	
		:	:	:	:	
<u>Pulses (Edible Grain Legumes)</u>	:	:	:	:	:	
India (New Delhi)	:	5.6	:	0.7	5.6	
Iran (Tehran)	:	4.0	:	0.7	4.0	
	Total Pulses	:	9.6	0.7	9.6	
		:	:	:	:	
<u>Total</u>	:	7.5	9.6	0.7	2.1	
		:	:	:	19.9	

Intramural program is supplemented by extramural support representing (a) 0.4 SMY's at State Agricultural Experiment Stations^{1/}, and (b) P.L. 480 funds in 1 country representing 103,223 U.S. dollars equivalent.

^{1/} RPA 205, 0.4.

Problems and Objectives

Newly developed varieties of beans, lima beans, and peas must be widely adapted, productive, of high quality, and suitable for mechanical harvesting. Since diseases are the major obstacle to increased production, the development of multiple-resistant varieties is being given top priority. Biological control of pests through breeding and other means are preferred when feasible to chemical methods. With increased acreage of southern peas, additional information is needed on disease control of this crop, and also for dry peas and lentils in the West. Because there is a need for increased production of pulse crops in developing countries to help reduce nutritional shortages, particularly protein, information is required on insect and disease control, varietal improvement, and better crop management practices.

Major objectives are to:

- (1) Develop disease-resistant varieties of dry and snap beans, lima beans, green and dry peas, cowpeas, and lentils.
- (2) Evaluate chemical and biological control of the diseases of these crops.
- (3) Identify virus diseases of peas and beans by serology, electron microscopy, and physical properties.
- (4) Study the ecology of the organisms causing pea root rot and search for resistance to the complex.
- (5) Develop high protein containing dry beans, dry peas, and lentils.

Progress - USDA and Cooperative Program

-- Beans and Lima Beans --

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. Dry Beans

In Washington, Royal Red, the first Red Kidney bean variety resistant to curly top and common bean mosaic viruses, was released. It is acceptable to canners and packagers. Approximately 25,000 pounds of registered seed is available to growers in the Columbia Basin. Progress continues in the development of Red Mexican, Pinto, Pink, and pea bean types with resistance to Fusarium root rot, common bean mosaic, and curly top.

In Michigan approximately 300 pea bean lines with resistance to mosaic and anthracnose were screened for Fusarium root rot resistance. About 130 showed more resistance than Sanilac and 11 more than the resistant parent.

Progress is being made in Michigan in the search for resistance to common and fuscous bacterial blights in pea beans. Many progenies from crosses between Nebraska No. 1 Great Northern Selection 27 and pea bean varieties are being tested. Thirty-five seedlings from a cross between tepary bean (resistant to the two bacterial diseases) and two pea bean varieties proved successful, with the aid of embryo culture techniques.

In Red Kidney bean types over 300 halo blight selections resistant to strains 1 and 2 were made. Three seedlings from an interspecific cross, Phaseolus acutifolius (tepary) x P. vulgaris vars. Redkote and Manitou, were obtained which will later be screened for resistance to fuscous and common blights using leaf cuttings.

Disease-Resistant Beans for El Salvador

The new black-seeded bean (No. 184) which resists mosaic, Alternaria, and several races of rust continued to perform in a presentable manner. Other selections are being made from 7 additional crosses which resist angular leaf spot, are tolerant to web blight, and resistant to mosaic and some races of rust. From over 1,000 P.I. lines, 17 have, in two tests, been found to resist the bean pod weevil, a serious pest in El Salvador and other Central American countries.

2. Snap Beans

In Washington, five of 39 multiple-resistant advanced breeding lines of snap beans appear to have potential as commercial varieties. One, 7C-34, was increased in Australia and Chile and will be tested by processors in 1968. About 1500 selections and small bulks of early generation material were screened for resistance to common mosaic, curly top, yellow mosaic, Fusarium root rot, and bacterial blight. Approximately 600 selections and 150 bulks were chosen. Many new hybrids have been made to upgrade Fusarium root rot resistance and to incorporate sources of bacterial blight resistance. Resistance to Rhizoctonia root rot and the root knot nematode is included in the breeding program.

3. Lima Beans

G 1 and G 2 green-seeded baby lima beans developed at Beltsville resisted strains A and B of downy mildew in field tests in New Jersey and Delaware in 1967 and outyielded Thaxter and Early Thorogreen in all trials. They were increased in Chile and Puerto Rico and approximately 1100 pounds of each will be further increased by seedsmen in California in 1968. Pilot test plantings and processing trials in New Jersey and Delaware will determine which line will be released.

Fifteen additional lines resistant to the two strains of downy mildew, superior in quality, and with darker green seeds than G 1 and G 2, are in the process of development.

The development of downy mildew-resistant, speckled-seeded types is progressing.

At Charleston, South Carolina, a high level of resistance to nematodes was retained in lima bean backcross progenies from the hybrid of Jackson Wonder x Nemagreen.

B. Nature and Control of Diseases

1. Virus Diseases

At Beltsville an apparently new strain of cucumber mosaic virus causing a severe green leaf mottle and distortion on lima bean was isolated from lima beans in Delaware and New Jersey in 1967. It appears to be related to the virus isolated in 1964 at Beltsville.

Another New Jersey virus isolated from lima beans causes a necrosis of the leaves and pods and from electron microscopic and serological evidence, it appears to be a new virulent strain of white clover mosaic virus. Most lima beans and all bean varieties were found to be susceptible. Most of the snap bean varieties were killed when inoculated in the seedling stage.

A strain of tobacco mosaic virus reported previously from Europe was isolated from greenhouse-grown beans at Beltsville. Systemic symptoms are very severe and resemble those produced by 2,4-D injury on beans. The virus has been found to infect all varieties of beans inoculated. It also infects certain other Phaseolus species.

2. Bacterial Diseases

Studies on chemical control of halo and common bacterial blights in Michigan have demonstrated the efficacy of copper sprays in reducing the severity of these diseases in beans. Oil added to the copper compounds at 1 qt/A enhanced their performance. Isolation from diseased bean samples showed that of 50 isolates, 29 were X. phaseoli, 15 P. phaseolicola, 5 X. phaseoli var. fuscans, and 1 P. syringae.

Toxin-containing filtrates of P. phaseolicola incorporated into tissue culture media at 10 percent v/v resulted in marked inhibition of callus tissue and excised root growth. Such inhibition is antagonized by the addition of .1 to .2 ppm kinetin.

At Beltsville, as in 1966, P. phaseolicola was recovered from infested soils only after the first 6 weeks. The pea blight organism, P. pisi, reacted similarly to P. syringae pathogenically and conversely the latter organism caused identical reactions on pea. The pea isolates used are phage specific and P. syringae phages can be used to separate P. syringae from P. pisi.

3. Fungus Diseases

At Washington root obstruction by hard subsoils was found to predispose bean plants to root rot. Breaking subsoils by 15" and 20" deep tillage reduced root rot and gave pronounced yield increases. Varietal differences in ability of roots to penetrate hard subsoils were correlated with differences in field tolerance to fusarium root rot. The Fusarium organism was found to be concentrated in the plowed layer of infested fields. Its occurrence below this layer was sparse. Continued studies on nitrogen fertilization revealed that neither NH_4^+N nor NO_3^- nor their combination aggravated the fusarium root rot organism. Increments of N from 40 to 260 lb/A in NH_4NO_3 or $\text{Ca}(\text{NO}_3)_2$ increased bean yields in fusarium infested fields. Maximum yields were obtained with only 130 lb N in $(\text{NH}_4)_2\text{SO}_4$ because this fertilizer remained positionally available to a larger part of the root system than did the other fertilizers which were more readily moved from the root zone by irrigation water.

In Michigan, of 7 soil fungicides tested for the control of bean root rot, only Terraclor E.C. at 2 qt/A increased plant stand and reduced root rot significantly.

At Salisbury, Maryland, Tenderwhite and several sister lines were the only bean varieties which resisted the races of rust present. Varieties which were heretofore resistant, such as Tennessee Green Pod and Seminole, were susceptible.

-- Peas and Lentils --

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. English Peas

a. Disease Resistance

In field tests in Washington from 150 lines, both hybrid and P.I. material, about 200 selections were made for further evaluation.

Of 428 lines, including P.I. lines and commercial varieties, screened for root rot tolerance, 52 were found to possess more tolerance to the root rot complex than the Perfected Wales check. No immune lines have yet been found.

Five lines possessed resistance to Pythium root rot.

b. Fungus Diseases

In Washington Pythium ultimum caused as much disease as Fusarium solani f. pisi at high soil moisture levels and soil temperatures of 13, 18, or 24°C.

Under soil moisture stress, F. solani f. pisi caused more disease than P. ultimum with soil temperatures of 18° or 24°C. Peas planted in soil maintained at 13, 18, or 24°C infested with both F. solani f. pisi and P. ultimum had as much or more disease than when planted in soil infested with either pathogen at any soil moisture level.

Five chemicals were applied to soil for pea root parasites. Although there was a substantial reduction in numbers of F. solani f. pisi and P. ultimum with Lanstan, there was no increase in yield or decrease in disease severity compared to the check.

c. Virus Diseases

In Oregon, transmission frequencies of pea streak virus (PSV) by the pea aphid of 50-60 percent were obtained in repeated experiments. A new host when inoculated with PSV by the pea aphid has been found to react diagnostically to this virus within 48 hours of inoculation permitting highly efficient evaluations by which legume viruses having elongated, flexuous rods can be effectively purified. This method is especially adapted for those viruses which are usually lost (60-90 percent loss) during initial clarification procedures. PSV and alfalfa mosaic virus (AMV) interact in peas to cause stunting and necrosis about 3-fold more severe than either virus alone.

2. Dry Peas

a. Disease Resistance

At Pullman, Washington, four yellow and 18 green-seeded dry pea lines were superior in yield to the controls. One green-seeded line produced almost 500 pounds and a yellow line about 200 pounds per acre more than the check. An additional 14 yellow and 15 green-seeded lines were chosen for the 1968 Uniform Nursery Trials. Thirty-two parental combinations for resistance to bleaching, frost, powdery mildew, yield, and high protein potential are included in about 450 lines of early generation material. In multi-tiller trials for increased yield, about 90 yellow- and 70 green-seeded lines were chosen.

b. Chemical Control

Seed treatments with Panogen 15 at .03 oz/bu and Dexon at .76 oz/bu each combined with Dieldrin at 2 oz/bu increased yields 100 to 130 lbs/A in Washington.

3. Lentils

a. Disease Resistance

Two large-seeded, high-yielding lentils were increased for breeders seed and may be released to growers in 1969 in Washington. The seeds measured 7.5 mm in diameter and with seed weights of 7.6 gms/100 seed vs. 5.75 mm and 5.3 mm/100 seed for the standard commercial variety.

b. Chemical Control

Treating seeds with Vitavax + Captan at 3 oz/bu, Gustafson D-P at .02 oz/bu, and SD 345 at .04 oz/bu increased yields 110 to 160 lbs/A.

-- Pulse Crops for the Near East --

RPA 603 - International Aid

A. Breeding and Genetics1. Irana. Beans, Chickpeas, and Cowpeas

Several strains of grain legumes were outstanding in yield tests and have been recommended to the Ministry of Agriculture for seed increase and release. These are:

- (1) White bean strain No. 49, originated in Shiraz area. It has out-yielded by an average of 15 percent other varieties in tests at 7 locations over 3 years.
- (2) Red bean strain No. 50, originating in Esfahan area, having an average of 20 percent greater yield.
- (3) Pinto bean strain No. 446 (Accession 65-071-00446), originating from Esfahan, yields equal to U.S. Pinto varieties but has a more acceptable seed type for the local market.
- (4) Chickpea strains No. 416 M and 438 M with yield advantages of 9 percent over the average of other varieties in the same tests.
- (5) Cowpea strains No. 50 and No. 4002. Strain 50 originated in Turkey; strain No. 4002 was collected in the Meshed area of Iran but it is unlike the indigenous material and so similar to some of the U.S. cowpea varieties like Blackeye No. 7 that its real origin is questionable.

b. Lentils

Small-seeded root rot-resistant strains of lentils from Esfahan and Fars produce yields approximately double those of large-seeded types in the absence of root rot symptoms. The yield difference is larger when root rot is severe. Some strains could be recommended for increase and release, but the market value of small-seeded types is low.

2. Indiaa. Mung Bean

The release of an early maturing variety of mung bean named Besaikhi was announced by the Indian Agricultural Research Institute. It appears to be

well suited as a summer crop between the end of wheat harvest in April and the beginning of Kharif planting in July.

b. Lathyrus Pea

Several lines of Khesari (Lathyrus sativus) have been found with from a trace to 0.15 percent of the neurotoxic compound, B-N-oxalyl amino alanine. These lines are presently being tested for possible direct use as varieties or as breeding material to help overcome the crippling effect of lathyrism in areas where this crop is grown and consumed.

B. Virus Diseases

1. Iran

a. Beans

Bean mosaic virus is transmitted in more than 50 percent of the seed of many bean varieties in Iran and yield reductions up to 70 percent were noted. Resistance was found in about 29 lines.

b. Broadbeans

No resistance to bean yellow mosaic virus was noted in 85 broadbean lines at Khuzestan, Iran. It was found to be seedborne in 0.2 percent of the seed. Yield reductions were found as high as 75-90 percent. A new virus known as broadbean yellows was found in 85 percent of the broadbean lines under test.

c. Chickpeas

In Iran, chickpeas are naturally infected by three viruses -- alfalfa mosaic, bean yellow mosaic, and cucumber mosaic viruses. None are seedborne but seed yields are heavily reduced by these viruses.

d. Cowpeas

A new seedborne virus is the most widely distributed disease of cowpeas. Yields of infected plants were reduced up to 80 percent. Six lines out of 54 tested were found to be resistant.

e. Mung Beans

(1) Virus Diseases. Mung bean mosaic virus is the most important disease of this crop. It is a flexuous rod, 750 μ in length, and appears to be a strain of common bean mosaic virus. Yields from virus-infected plants were decreased up to 75 percent. Rhizoctonia solani was responsible for over 50 percent mortality in young mung bean seedlings.

(2) Nematodes. Studies on nematodes conducted in cooperation with the Ministry of Agriculture, Plant Pest Control Institute, showed degrees of resistance to the root knot nematode among 10 varieties of mung beans.

2. India

a. Chickpeas

Chickpea wilt, probably the most destructive disease of this crop, is due to a complex of several organisms. Two pathogens have been definitely identified. No satisfactory resistance has yet been found.

b. Pigeon Peas

Pigeon pea wilt causes an estimated loss of 40 million rupees or 2600 metric tons of grain. Development of resistant varieties appears feasible. Studies have been conducted on the presence of different strains of the pathogen. Some 600 collections of wilted plants were made and isolates obtained from them. Breeding material is being screened for resistance.

c. Mung Beans

Out of 681 mung beans, 203 showed field resistance to yellow mosaic, 264 to leaf crinkle, and 9 to bacterial blight.

Among 20 varieties of mung beans, two had acceptable field resistance to 6 serious diseases.

d. Urd Bean

Of 310 urd bean lines screened for virus resistance, 67 had some resistance to yellow mosaic, 172 to leaf crinkle, and several showed varying degrees of resistance to fungal and bacterial diseases.

e. Cowpeas

Two viruses have been isolated from cowpeas. Studies on their specific identification are in progress.

-- Variety Evaluation and Physiology --

RPA 402 - IMPROVED CONSUMER ACCEPTABILITY

Detection of Quality Factors in Beans

Paper chromatograms of flavanoids from beans of 18 varieties confirm the presence of a kaempferol glucoside in bush types and its absence from pole types. Chromatograms of leaves from the variety Polaris are identical to those from a white-seeded Kentucky Wonder; both varieties being pole types.

Gas chromatograms of oils extracted from pods show obvious quantitative differences among 5 varieties.

Publications - USDA and Cooperative Program

RPA 205 - CONTROL OF DISEASES

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RPA 603 - INTERNATIONAL AID

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RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

Breeding and Genetics

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Physiology and Culture

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TOMATO, PEPPER, AND RELATED CROP BREEDING, GENETICS,
DISEASES, AND CULTURE

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968					
	Research Problem Area			Total		
	304	205	204	402		
<u>Tomato</u>	:	:	:	:	:	:
Maryland (Beltsville)	:	-	1.0	0.8	0.8	2.6
Georgia	:	0.3	0.7	-	0.6	1.6
South Carolina	:	0.6	0.2	-	0.2	1.0
Utah	:	0.1	0.1	-	0.1	0.3
Washington	:	-	1.5	-	-	1.5
Wyoming	:	-	0.4	-	-	0.4
Total Tomato	:	1.0	3.9	0.8	1.7	7.4
<u>Pepper</u>	:	:	:	:	:	:
Maryland (Beltsville)	:	-	0.1	0.1	0.1	0.3
Georgia	:	0.1	0.2	-	0.1	0.4
Washington	:	-	0.2	-	-	0.2
Total Pepper	:	0.1	0.5	0.1	0.2	0.9
Total	:	1.1	4.4	0.9	1.9	8.3

Intramural program is supplemented by extramural support representing (a) 0.5 SMY's at State Agricultural Experiment Stations^{1/}; (b) 0.0 SMY's at other U.S. institutions; and (c) P.L. 480 funds in 1 country (Yugoslavia - pepper) representing \$57,216.00 U.S. dollars equivalent.

^{1/} RPA 205 0.5

Problems and Objectives

The rapid progress toward total mechanization of the tomato harvest has forced drastic changes in tomato-improvement programs. Disease- and insect-resistant, prolific-fruited, small-vined, early-maturing varieties of high processing and fresh market quality adapted to machine harvesting are needed now, particularly in all areas east of the Rocky Mountains and in the Pacific Northwest. Total mechanization of the ripe pepper harvest is a necessity to compete with foreign imports. Mechanization of the Southern tomato and transplant harvest is necessary to economically achieve mechanization of the fruit harvest in areas east of the Rocky Mountains.

Major objectives of the research are:

- (1) Develop machine harvestable, multiple pest-resistant breeding lines, varieties, and hybrids adapted to the various production areas for specific uses.
- (2) Identify new disease and insect pests and search for resistant germ plasm in domestic and wild species.
- (3) Determine genetic basis for resistance to disease and insect pests.
- (4) Improve fruit quality through breeding.
- (5) Develop improved seeding, nutritional, cultural, and other management practices to assist in the mechanization of the Southern transplant industry.

Progress - USDA and Cooperative Program

-- Tomato --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. A new variety developed. "Parker," an early, disease-resistant, paste-type, suitable to mechanical harvesting, and highly acceptable for products and canning whole is being released to primary seed producers in 1968.
2. Improved breeding line developed. Breeding line, B833, a midseason, high-yielding, round-fruited type with resistances to at least 2 insects (spider mites and potato aphid), 3 major diseases (Verticillium and Fusarium wilts and gray leaf spot), and field tolerance to early blight will be released to public and private breeders in 1968.

3. Breeding for mechanization of the harvest. Approximately 200 multiple pest-resistant lines with potential for mechanization of the harvest were evaluated for machineability of fruit. Thirty-five withstood rigors of machine harvesting. Most of these were mid- to late-season types. One hundred and ninety-nine selections made especially for earliness, compactness of vine, jointless pedicel and resiliency of fruit were increased in Puerto Rico for larger scale machine harvest trials in 1968.

B. Culture and Physiology

1. Improved transplant production. Transplants of 5 major tomato cultivars used in tomato processing were grown under practices including plant clipping that insured maximum plant uniformity in plant beds were grown in performance trials in Northern production areas. Results indicate that advanced technology in transplant production vastly improves the number and uniformity of transplants and assists mechanization of the harvest in Northern areas.

2. Physiology and biochemistry of curly top resistance in tomato. A procedure has been developed to isolate and identify specific strains of the curly top virus from a natural strain complex. Studies indicate that 7 isolates are distinct strains. These are being used to define precisely the reaction of currently-used, resistant germ plasm to specific strains of the virus. Also, the ability of the leaf hopper to retain specific strains of the curly top virus over long periods is under investigation.

In cooperation with the University of California (Berkeley), auxins have been found to be in reduced concentration in curly top diseased plants and labeled auxins are transported more slowly in diseased plants.

Curly top virus infection has been found to enhance susceptibility of tomato plants to *Verticillium* and *Fusarium* wilt organisms. Curly top infection was found to cause shortening and thickening of roots. Later diseased roots become brown. Leaves of affected plants become twisted and rolled. This symptom syndrome can be reproduced by certain concentrations of ethylene gas.

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. Breeding for curly top resistance in tomato. In cooperation with Utah and Washington, a high level of resistance to curly top has been stabilized in several breeding lines with promising horticultural potentials. These lines, when crossed with commercial varieties, produce progenies with vine, fruit, and maturity characteristics that appear promising for mechanization of the harvest in areas where curly top is a production problem.

2. Breeding for resistance to bacterial canker. In cooperation with Wyoming, 45 tomato lines were evaluated for resistance to bacterial canker

in the greenhouse. Several lines showed tolerance and one line equaled or surpassed the resistance found earlier in accessions from Bulgaria.

3. Breeding for resistance to fruit rots. Four tomato lines that appeared highly resistant to fruit rots in 1966 were evaluated with F_1 and F_2 populations in 1967. Fruit rotting in 1967 was very severe and the 4 lines and most progenies proved quite susceptible.

About 120 Lycopersicon P.I. accessions were evaluated for resistance to anthracnose. From field and laboratory assays, about 30 "less susceptible" selections were made for crossing and further tests in 1968.

Several breeding lines and varieties developed in certain Southern states appeared promising as germ plasm for resistance to Rhizoctonia and Phytophthora (soil) fruit rots.

4. Breeding for resistance to nematodes. Approximately 60 lines resistant to the root knot nematode and possessing resistance to 3 major diseases are in machine harvest trials at Beltsville. Attempts to transfer resistance to Meloidogyne hapla from Lycopersicon peruvianum to commercial types is in progress.

B. Southern Bacterial Wilt and Stem Rot in Southern Transplants

1. Transmission of bacterial wilt organism through plant clipping. Transmission of the bacterial wilt organism from diseased to healthy transplants can be accomplished through simulated plant clipping.

2. Distribution of Southern bacterial wilt in transplant soils in Georgia. Greatest concentrations of the bacterium was in the upper 12 inches of soil, at a lesser concentration at the 12-18 inch depth, and in one instance at a depth of 30 inches. This exemplifies problems associated with control through soil fumigation.

3. Identity of pathogens causing stem rot of tomato transplants in Georgia. Pythium myriotylum in addition to P. aphanidermatum has been found associated with stem rot of tomato. Studies on temperature requirements for infection indicate both organisms are pathogens in the stem rot complex. Host range studies indicate that several crops normally used in crop rotations with transplants are hosts for both organisms.

RPA 204 - CONTROL OF INSECT PESTS

A. Breeding and Genetics

1. Breeding for resistance to insect pests of tomato. In cooperation with the Entomology Research Division, techniques have been developed to evaluate resistance in tomato to major insect pests. One breeding line, B833, was found to possess resistance to the spider mite and potato aphid in addition

to resistance to disease. This line is being released to breeders. Studies on inheritance to specific insects is continuing.

RPA 402 - PRODUCTION OF FRUIT AND VEGETABLE CROPS WITH IMPROVED CONSUMER ACCEPTABILITY

A. Breeding and Genetics

1. Fruit color linkage studies. Linkage studies of color factors in tomatoes show the crimson gene (og^c) to be independent of the apricot gene at. The tangerine mutant, tt, was epistatic to og^c. No difference, either qualitative or quantitative, could be detected in the pigment contents of the tt and tt og^c og^c types.

-- Pepper --

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. Resistance to cucumber mosaic virus found in wild pepper. Two strains of Capsicum frutescens L. from Columbia, South America, have been found resistant to the cucumber mosaic virus. These two lines do not cross readily with the commercial C. annuum but some F₁ seed have been obtained.

Publications - USDA and Cooperative Program

-- Tomatoes --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

Breeding and Genetics

Webb, R. E. 1968. Performance of tomato varieties in 1967. Vegetable Growers Messenger 20:5.

Culture and Physiology

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Jaworski, C. A., R. E. Webb, and D. J. Morton. 1967. Effects of storage and nutrition on tomato transplant quality, survival, and fruit yield. Hort. Res. 7:90-96.

Jaworski, C. A., and R. E. Webb. 1967. Preliminary tests on the performance of clipped tomato transplants. Proc. Amer. Soc. Hort. Sci. 91:550-555.

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RPA 205 - CONTROL OF DISEASES

Breeding and Genetics

Barksdale, T. H. 1968. Rhizoctonia soil rot and buckeye rot of tomatoes: Observational differences in susceptibility. Plant Dis. Repr. 52:284-286.

Dropkin, V. H., D. W. Davis, and R. E. Webb. 1967. Resistance of tomatoes to Meloidogyne incognita acrita and M. hapla (root knot nematodes) as determined by a new technique. Amer. Soc. Hort. Sci. 90:316-323.

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Thyr, B. D. 1968. Resistance to bacterial canker in tomato, and its evaluation. Phytopathology 58:279-281.

Physiology

Littrell, R. H., and S. M. McCarter. 1968. Effect of soil temperature on pathogenicity of Pythium aphanidermatum and Pythium myriotylum to rye and tomato seedlings. Phytopathology 58:730 (Abstr.).

McCarter, S. M., and R. H. Littrell. 1967. Influence of temperature on the liberation, motility and germination of zoospores of Pythium aphanidermatum and Pythium myriotylum. Phytopathology 57:821 (Abstr.).

Southern Bacterial Wilt and Stem Rot

McCarter, S. M., and R. H. Littrell. 1968. Pathogenicity of Pythium myriotylum to several grass and vegetable crops. Plant Dis. Repr. 52: 179-183.

McCarter, S. M., and C. A. Jaworski. 1968. Greenhouse studies on the spread of Pseudomonas solanacearum in tomato plants by clipping. Plant Dis. Repr. 52:330-334.

McCarter, S. M., and R. H. Littrell. 1968. Comparative virulence of various isolates of Pythium aphanidermatum and Pythium myriotylum to selected plant species. Bull. Ga. Acad. Sci. 26:59-60.

RPA 204 - CONTROL OF INSECT PESTS

Breeding and Genetics

Gentile, A. G., and A. K. Stoner. 1968. Damage by larvae of the tobacco flea beetle to tomato seedlings. J. Econ. Entomol. 61:152-154.

Stoner, A. K., and T. Stringfellow. 1967. Resistance of tomato varieties to spider mites. Proc. Amer. Soc. Hort. Sci. 90:324-329.

Stoner, A. K., and A. G. Gentile. 1967. Tomato seedling damage inflicted by tobacco flea beetle larvae. HortScience 2:158-159.

LEAFY AND MISCELLANEOUS VEGETABLES BREEDING
AND GENETICS AND DISEASES

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968			Total	
	Research Problem Area				
	304	205	402		
Lettuce	:	:	:	:	
California	:	-	0.9	0.8	
Texas	:	-	0.1	0.1	
Total Lettuce	:	-	1.0	0.9	
	:	:	:	:	
Spinach	:	:	:	:	
Maryland (Beltsville)	:	-	0.1	-	
	:	:	:	:	
Broccoli and Cabbage	:	:	:	:	
South Carolina	:	0.3	0.2	0.3	
Total	:	0.3	1.3	1.2	
				2.8	

No extramural support.

Problems and Objectives

Growers and shippers of the lettuce industry have the well deserved reputation for quickly translating research results into day-to-day operational practices. Sprinkler irrigation as a means of obtaining uniform germination was in the experimental stage only a short time ago. Today it is an accepted practice as more and more growers turn to this method of irrigation for vigorous, uniform stands. The program is geared to insure the grower minimum losses from pests by developing high quality adapted varieties of lettuce, spinach, and other leafy vegetables resistant to disease and insect pests. Spinach research is chiefly concerned with the development of adapted, longstanding varieties resistant to two devastating diseases of this crop, mildew and rust.

Major objectives of the research are:

- (1) Develop varieties and lines of lettuce and spinach with disease and insect resistance, of high quality, and suitable for mechanical production and harvest.
- (2) Develop basic information on genetics and cytogenetics of lettuce.

Progress - USDA and Cooperative Program

-- Lettuce --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Improvement of uniformity. In a study of uniformity, two experiments involving comparison of an F_1 hybrid with its parents were grown in the greenhouse: 6056 male sterile x Calmar, and Calmar male sterile x Vanguard.
2. Basic genetic studies. The inheritance of three characters was determined. They are: albinism, golden flower, and pear-shaped involucre. All are simple recessives. Studies on the inheritance of two male sterile characters continues. A third male sterile was discovered in a wild lettuce line.
3. Release of two new head lettuce varieties. In cooperation with the Texas Agricultural Experiment Station, two head lettuce varieties, Valtemp (M-5) and Valrio (M-16), were released. Valtemp is an early-season variety, more resistant to high temperatures and premature bolting than comparable commercial varieties. It is also more resistant to downy mildew and cold damage than present varieties. Valrio is a midseason variety highly resistant to downy mildew and cold damage. In addition, Valrio has the capacity to produce large, firm heads under cool temperatures. Observations

indicate that short intervals of unreasonably warm weather have no adverse effects on this variety.

An early-season planting of one-acre blocks each of M-5 (Valtemp), M-6, Great Lakes 659, and Great Lakes 66, demonstrated that Valtemp produced the best quality lettuce. Both Great Lakes 659 and Great Lakes 66 had mildew lesions on all plants while no mildew could be found on Valtemp or M-6. A nearby planting of Calmar was heavily damaged by downy mildew. Six mid-to late-season plantings of Valrio (M-16) were made in comparison with Great Lakes 66 and Valverde. Valrio was superior in quality, head size, color, and yield in all tests. In two plantings maturing in March there was light to heavy infection of downy mildew on Valrio. Adjoining commercial varieties and breeding lines, however, were all heavily infected with the fungus.

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. Breeding for mosaic resistance. Mosaic resistance from three wild P.I. collections from Egypt and from the variety Gallega is being backcrossed into three varieties of head lettuce, Great Lakes 118, Calmar, and Vanguard. The wild type resistance is now in bc_3 in Vanguard, bc_2 in Great Lakes 118, and bc_1 in Calmar. The Gallega resistance is in bc_1 in all three varieties. A third source of resistance from a line treated with ethyl methane sulfonate (EMS) has been crossed with the same three varieties. In addition, the three sources of resistance have been intercrossed in all combinations and with susceptible lines to determine the genetic basis for each. Screening for other types of resistance continues with testing during the past year of 83 commercial varieties, 221 unnamed breeding lines, 31 P.I. collections, and 80 irradiated lines. The variety Fordhook, probably a synonym of Gallega, and two numbered lines from France derived from Gallega were resistant; the remainder were susceptible.

2. Selecting for downy mildew resistance. Breeding lines selected from the following Plant Introduction numbers have shown no infection after 3 years of intensive screening with the races of downy mildew now prevalent in the Lower Rio Grande Valley of Texas. They are: P.I. 250425, P.I. 273606, P.I. 274369, P.I. 274373, and P.I. 274900. Preliminary tests suggest that Variety A from Wisconsin, and the varieties Ventura, Meikoningin, and Proeftuins Blackpool may also be resistant.

B. Disease Occurrence

1. Occurrence of powdery mildew on lettuce in the Lower Rio Grande Valley of Texas. Powdery mildew was found in the breeding plots and in the greenhouse in April. This is the first reported occurrence of powdery mildew on lettuce in the Lower Rio Grande Valley. As in other areas, it is unlikely to become a serious disease of lettuce in the Lower Rio Grande

Valley. It was easily controlled in the greenhouse by the application of a fungicide.

-- Spinach --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Gynomonoecious line development. Gynomonoecious line (predominantly pistillate but with some staminate flowers produced late in the season) were developed at Beltsville. Four of these lines produced seed. Two lines were used in hybrid seed production without the customary roguing (removing of males from seed parent). Extensive combining tests with one gynomonoecious line, 66S9, and 7 dioecious lines suggest that the use of gynomonoecious lines as seed parents is practical in hybrid seed production.
2. Varietal release. Norgreen, a mildew-resistant, longstanding, flat-leaf variety was released to seedsmen. It is adapted to spring production in the mid-South and eastern seaboard, and summer production in the Pacific Northwest. Norgreen is comparable in quality to the mildew-susceptible variety Northland. Norgreen outyields Northland by 1 to 3 tons per acre even when mildew is not a problem.

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. Development of longstanding, mildew-resistant lines. Three flat-leaf lines, with different dates of maturity, and two savoy types were developed. As a result of trials, two flat-leaf and one savoy line will be released to seedsmen as varieties, and the remaining two as breeding lines to public and private breeders.
2. Breeding for resistance to white rust. Sixty-two F_1 and F_2 populations, and advanced generations were exposed to natural infection with the white rust organism. Nineteen lines were harvestable about 5 weeks after the susceptible controls were unfit for harvest.

-- Broccoli and Cabbage --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Breeding for uniformity in broccoli. The broccoli breeding line B1732 produces segregants in which the side shoots are ready to harvest at the same time as the central head; whereas, in common varieties the central head must be cut before the side shoots develop fully.

Publications - USDA and Cooperative Program

-- Lettuce --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

Ryder, E. G. 1967. A recessive male sterility gene in lettuce (Lactuca sativa L.). Proc. Amer. Soc. Hort. Sci. 91:366-368.

Whitaker, Thomas W. 1968. A chlorophyll deficient mutant in lettuce. Vegetable Improvement Newsletter No. 10:5. Feb. 29.

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

Ryder, E. J. 1968. Evaluation of lettuce varieties and breeding lines for resistance to common lettuce mosaic. USDA Tech. Bull. 1391. 8 pp.

MUSKMELON AND OTHER CUCURBIT BREEDING AND GENETICS,
DISEASES, AND VARIETY EVALUATION

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968				
	Research Problem Area				Total
	304	205	204	402	
<u>Cucurbits</u>	:	:	:	:	:
Maryland (Beltsville)	:	-	:	-	:
Arizona	:	-	:	-	:
California	:	-	:	0.7	:
South Carolina	:	1.2	:	0.8	:
Texas	:	-	:	0.6	:
Wyoming	:	0.1	:	0.3	:
Total	:	1.3	:	2.4	:
				0.6	1.5
					5.8

Intramural program is supplemented by P.L. 480 funds in 3 countries representing \$112,432.91 U.S. dollars equivalent.

Problems and Objectives

Susceptibility to diseases and insects, lack of adaptation to growing conditions, urgent need of varieties to mechanize the harvest, and poor edible and shipping fruit quality of present-day varieties are the major problems confronting the melon industry.

Major objectives of the research are:

- (1) Develop small-vined, multiple pest-resistant, high yielding, high quality, widely adapted varieties that are harvestable by machine.
- (2) Determine means to improve the production of hybrid seed, particularly in muskmelon and watermelon.
- (3) Obtain germ plasm highly resistant to major virus and root rot diseases.
- (4) Improve melon fruit quality including edible and shipping characteristics.
- (5) Determine causal agents and develop means for control of the "crown blight" disease of cantaloup in the Southwest.

Progress - USDA and Cooperative Program

-- Cantaloup --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Two disease-resistant honey dews developed. Charleston C77, a powdery mildew-resistant honey dew, appears capable of producing high yields and good quality in the humid Southeastern States where previously this type of melon could not be grown successfully.

A high quality, powdery mildew-resistant, and crown blight-resistant honey dew breeding line was later maturing than commercial honey dew in central California plantings.

2. Large-fruited, disease-resistant cantaloup developed. Downy mildew-resistant Jumbo cantaloup No. 67-1, developed at USDA Southeastern Vegetable Breeding Laboratory, received strong endorsements from growers in the Southeast.

3. Mechanical harvesting. Stocks with growth and fruiting habits unlike those associated with the b gene for brachytic bush habit were accumulated as potentially useful parents of muskmelons for mechanical harvesting.

4. A new seedling marker. Red stem pigment was found to be simply inherited. This is the first red pigment found in stem or leaf of any cucurbit. Preliminary studies by three University of California biochemists indicate that it differs from other red plant pigments. This and other seedling markers are being incorporated into breeding lines to assist in identification of economic characters such as resistance to specific diseases, male sterility, and F_1 hybrid seedlings.

5. Development of breeding methods. (1) Within-generation correlations in 18 populations indicated pleiotropy or close linkage of genes for fruit mass characters (weight, size, and diameter) and of genes for fruit appearance characters (appearance, net distribution, net size, and freedom from bare sutures). Low correlations for other character relationships suggested that linkage would not prevent progress from continued mass selection. However, greater variation in correlations among inbred populations, compared with mass selected populations, indicated that such linkages do occur. (2) In cooperation with the Arizona Agricultural Experiment Station, Mesa, it has been found that F_1 progeny of crosses between firm-flesh cultivars and soft-flesh, crown blight-resistant breeding lines had firm flesh and an economically significant degree of crown blight resistance. (3) Cooperation among muskmelon breeders in Texas, the Far West, and the Southeast yielded six new varieties: Wescan, Campo, Jacumba, Perlita, Gulfstream, and Dulce. The program yielded, also, new testing, evaluation, and selection techniques, helped to define the limitations of regional adaptation, and created a widely useful rating system for muskmelons.

6. Interspecific hybridization. Interspecific hybridization tests in Cucumis have been terminated pending the collection of new material of species closely related to C. melo. While we were not able to achieve our primary goal of establishing gene flow between C. melo and the wild species of Cucumis, we did delineate 6 groups among the approximately 20 species investigated. These groups are based upon breeding behavior, morphological, and chemical similarities.

7. Experimental morphogenesis in cucurbits. In a P.L. 480 grant with Israel, studies were continued on the nature of sex differentiation in cucumber and cantaloup. Inheritance of the gynecious character in cantaloup was found to be complex.

8. Technique to identify Cucumis spp. and hybrids. Paper chromatograms of flavonoid chemicals from leaves of 19 species of Cucumis and 17 species hybrids show that chemical differences may be of value in species and hybrid identification.

RPA 205 - CONTROL OF DISEASES

A. Breeding and Genetics

1. Resistance to cucumber mosaic virus. The delayed backcross program was continued to transfer multiple-factor resistance to CMV into PMR cantaloup

and PMR honey dew. Plants resistant to infection by the airbrush inoculation technique were also resistant to graft transfer of the virus.

2. Resistance to watermelon mosaic virus. The successive backcross program was continued to transfer dominant-factor resistance to WMV-1 into PMR cantaloup and PMR honey dew. Plants resistant to systemic infection by airbrush inoculation were also resistant to graft transfer of the virus. Plants resistant to WMV-1 were naturally infected with WMV-2 at Brawley, California. Resistance to both strains of the virus will be required for successful control of WMV in the field.

3. Resistance to nematodes in *Cucumis* species. Attempts to transfer nematode resistance from wild species of *Cucumis* to cantaloup were not successful.

B. Virus Transmission

1. Studies on the mode of natural transmission of the tobacco ringspot virus. Transmission of the tobacco ringspot virus by spider mites (*Tetranychus* spp.) to several hosts has been successfully demonstrated in about 3 percent of the total attempts. Since there are few of the *Xiphinema* nematode vector of tobacco ringspot virus in south Texas, the spider mite may be the principal natural vector of this virus in that area.

Luffa acutangula was found to be a new host for the tobacco ringspot virus.

-- Watermelon --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Improved method for increase of seedstocks and triploid seed production. A low cost routine has been developed for the production of 3X hybrid watermelon seed and the marketing of seedless watermelons. Seed of 2X and 4X can be increased simultaneously in the same plot, and 3X seed are a by-product to be used by market growers.

RPA 205 - CONTROL OF DISEASES

A. Disease-Causal Agent Association

1. Blossom-end rot. Blossom-end rot of watermelon fruit was found to be closely associated with plant infection by the tobacco ringspot virus.

RPA 204 - CONTROL OF INSECT PESTS

A. Breeding and Genetics

1. Resistance to cucumber beetle found. Inheritance studies on watermelon and cantaloup indicated seedling resistance to the cucumber beetle (Diabrotica balteata) is controlled by a single major recessive gene.
2. Efficient technique developed. Cucurbitacin, an alkaloid commonly found in cucurbits, was found to be in high concentration in cucurbits that are highly resistant to the cucumber beetle. A spectrophotometric technique was developed which will permit the measurement of cucurbitacin in single cotyledons of melon seedling populations.

-- Squash --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

A. Breeding and Genetics

1. Interspecific hybridization. A study of the biology of 4 xerophytic species of Cucurbita has been completed.
2. Numerical taxonomy. Several statistical techniques of numerical taxonomy were studied using 21 species of Cucurbita as models. The distance and divergence coefficients were more closely correlated with cross compatibility ratings than were the Q-correlation coefficients. On the other hand, phenograms derived from Q-correlation coefficients were in closer general agreement with a combination of biological factors such as cross compatibility, geographical distribution, and ecological adaptation than were phenograms derived from distance or divergence coefficients.

Publications - USDA and Cooperative Program

-- Cantaloup --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

Breeding and Genetics

Andrus, C. F. 1968. A white flower cantaloup. Vegetable Improvement Newsletter 10:8.

Bohn, G. W. 1968. Pseudo-cleistogamy in the muskmelon Cucumis melo L. Vegetable Improvement Newsletter 10:6-7.

Bohn, G. W. 1968. A red pigment in muskmelon. Vegetable Improvement Newsletter 10:7-8.

Chambliss, O. L., and F. P. Cuthbert. 1968. Cucumber beetle-resistant cucurbits. Vegetable Improvement Newsletter 10:4.

RPA 205 - CONTROL OF DISEASES

Disease Causal Agent Identification

Thomas, C. E. 1968. Luffa acutangula, a new host for tobacco ringspot virus. Plant Dis. Repr. 52:374.

_____. 1968. Bacterial rind necrosis of watermelon in south Texas. Plant Dis. Repr. 52:375-377.

-- Squash --

RPA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY

Breeding and Genetics

Cutler, Hugh C., and Thomas W. Whitaker. 1967. Cucurbits from the Tehuacan Caves. In Prehistory of the Tehuacan Valley: Environment and subsistence 1:212-219.

Whitaker, Thomas W. 1968. Ecological aspects of the cultivated Cucurbita. HortScience 3:9-11.

Whitaker, Thomas W. 1968. Gourds and gardeners. Flower and Garden, January, pp. 9, 11, 46.

RPA 205 - CONTROL OF DISEASES

Fungicide Efficiency

Paulus, A. O., F. Shibuya, T. W. Whitaker, B. J. Hall, G. W. Bohn, and T. M. Little. 1968. Control of powdery mildew...in cucumber...in squash. Calif. Agr. 22:10-11.

ORNAMENTAL PLANTS, BREEDING AND GENETICS,
DISEASES, CULTURE AND PHYSIOLOGY

Crops Research Division, ARS

(RPA 906 - CULTURE AND PROTECTION OF ORNAMENTALS AND TURF)

USDA and Cooperative Program

Location of intramural work	Scientist man-years FY 1968
Maryland (Beltsville)	9.7
District of Columbia	7.4
Georgia	1.0
Washington	-
Wyoming	0.8
Total	18.9

Intramural program is supplemented by extramural support representing (a) 0.2 SMY's at State Agricultural Experiment Stations, (b) 0.4 SMY's at other U. S. institutions and (c) P.L. 480 funds in 1 country representing \$40,000 U. S. dollars equivalent.

Problems and Objectives

The production of ornamental plants grown by florists and nurserymen involves numerous technical problems which may occur during all aspects of the highly varied and numerous growing and selling operations. Cultivars with inherent resistance to disease and insects which are adapted to the expanding urban environment are needed. More precise control of the growth and the timing of crops should be developed to increase efficiency and to meet specific market demands. The great expansion of commercial, out-of-door cut flower and nursery production and the construction of highly mechanized and automated greenhouses throughout the country bring about many new and unique problems. Explosive urbanization and expanding national, State, and local interest in civic beautification create new and urgent need for basic and applied research in the ornamental plant industry.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Conducting genetic and cytological studies, including induced polyploidy, to develop new and improved cultivars useful for further breeding by commercial breeders of ornamental plants.
2. Determining optimum cultural, forcing, and post-harvest conditions for regulating flowering of ornamental plants.
3. Investigating the causal agents and develop control measures for diseases of florist and nursery crops and other ornamental plants.

Progress - USDA and Cooperative Programs

A. Breeding and Genetics

1. African Violets. In Saintpaulia, the morphological differences between diploid, tetraploid, and cytochimeral forms were found to be due to differences in cell sizes in certain histogenic layers.

2. Azaleas. Complete tetraploids from chimeral azalea plants were isolated. These complete tetraploids are being increased to make these superior plants available to nurserymen. Other commercial varieties are being treated with colchicine to improve their form, texture, and substance. A triploid azalea was discovered in one of the azalea series; this has not been reported previously.

Matings of the Exbury hybrids with R. atlanticum have resulted in selections with improved foliage, habit and ease of propagation in a reasonably wide color range. Combinations with such late flowering species as R. bakeri, prunifolium, and serrulatum have resulted in promising selections flowering in late June, July, and early August.

3. Camellia. Eight flower buds each of 170 varieties of Camellia japonica were fall-treated with gibberellic acid to induce November bloom within

this usually spring-flowering species. It was found that nearly one-third of the treated buds opened and that 80% of these produced flowers of average to superior quality before killing frosts in late November. With a few notable exceptions, the most responsive varieties were those which are normally early to flower in spring.

4. Carnations. At Cheyenne, Wyo., 2-4-4 carnation cytochimeras can produce both diploid and polyploid plants when crossed with plants of like ploidy. This breeding behavior is due either to sectors of 2-2-2 or 2-2-4 composition and coincidental production of some polyploid gametes or, in 2-4-4 cytochimeras, to gametes produced from both layer I and II. Seed production and seed germination in polyploid carnations is very low due to defective balance in the cytological behavior of autotetraploids and allotetraploids.

5. Chrysanthemum. Flowers on adventitious shoots from a number of the Indianapolis varieties of chrysanthemum have been of a different color than the parent varieties which were apparently periclinal chimeras. These adventitious shoots are from a single cell and do not show the frequent sectoring of the parent chimeral varieties. However, two Indianapolis varieties have yielded adventitious shoots of the parent color and with sectors. These two varieties are apparently not chimeras. There must be more than one mechanism for the production of the frequent sectors in Indianapolis chrysanthemums.

6. Crapemyrtle. Inter- and intraspecific crossing has continued during an especially good flowering season. Two further selections, 'Cherokee' and 'Seminole', are being propagated for 1968 release.

7. Hemerocallis. In Hemerocallis the genes for anthocyanins are dominant. Genes for delphinidins and cyanidins are present in the varieties, but these could segregate giving clearer reds or lavenders.

Selfed seedlings of Hemerocallis normally lack vigor and may require 4 or 5 years before they bloom while crossed seedlings bloom in 2 years.

Hexaploidy is not known in Hemerocallis and has not been produced artificially. Colchicine treated triploids show a small percentage of sectorial chimeras indicating that it might be possible to isolate permanent cytochimeral or complete hexaploids in the future. The sectors were identified by stomatal size and by chromosome counts.

8. Holly. Two interspecific hybrid cultivars have been released. Resulting from the hybridization of the American native species, Ilex myrtifolia and I. opaca, the cultivars 'Tanager' and 'Oriole' are evergreen and red-fruited. Both of these female selections are also slow-growing, compact, fine-textured, and suitable for the small property landscape.

9. Lilies. Cytological verification was obtained on the presumed back-crosses involving both forms of L. speciosum (album and rubrum) and diploid

L. x 'Black Beauty' pollen. This represents the first proven instance of seed having been produced from use of 'Black Beauty' (species hybrid) as either the pollen or seed plant parent.

10. Pigments. Anthocyanins in 'Better Times' rose, 'Potomac' rose, snap-dragon, and 8 different poinsettias were examined spectrophotometrically, using both fresh tissue and tissue extracts on thin layer chromatographic plates. The goal was to relate color as seen by the eye to the instrumental analyses which showed the kinds and the amounts of anthocyanins present. Different colors caused by different anthocyanins gave the same absorption maxima in fresh tissue. From qualitative and quantitative chromatographic analysis of anthocyanins one could not predict the color of the fresh tissue. The same anthocyanin must exist in different states in different tissues. Genes, which determine the kind, amount, and form of the pigment regulate the ultimate expression of pigments.

11. Poinsettia. Clon selections.--One phase of the poinsettia breeding program has been selection towards the extremes of bract color, both to improve the Christmas reds and to find new colors more useful for flowering at other times. Pink seedlings have been obtained only from a mutant collected in Mexico which is linked to a number of undesirable characteristics. One breeding line has been selected toward clear, pale reds. A cross between sister seedlings gave two seedlings which were a bright, clear pink, similar to but without the undesirable characteristics of the Mexican pink. These new pink seedlings are a major step toward a useful commercial pink variety.

Seed production.--A family of poinsettia seedlings of relatively uniform quality whose parent were relatively fertile were judged sufficiently advanced to warrant extensive trial of growing commercial type plants from seed. Over 600 seed have been produced from the same cross and are being planted to test several schedules of producing various sizes of potted plants for December flowering.

Breeding.--Of the six poinsettias sent out for commercial trial in 1967-68, one and possibly two have been judged worthy of introduction as commercial cultivars.

Four new lines of poinsettia breeding material are being released to commercial breeders and to experiment stations.

12. Privet. The stability and independence of the several histogenic layers in the growing point of privet and tobacco profoundly influences the survival and possible exploitation of somatic mutations. Periclinal chimeras with plastid mutants in the internal layers have been studied. The frequency of replacement of layer I by layer II in the ontogeny of leaves and anthers is approximately 1 in 4000 cell divisions in each organ.

13. Ultrastructure of Breeding Material. Observations were made of chimeral material in the electron microscope using ultra-thin sections of shoot tips of poinsettia, ivy, and geranium. No structural differences in mutant proplastids have been identified.

B. Diseases

1. Bedding Plants. At Tifton, Ga., snapdragon plants in seed beds were protected from Phytophthora parasitica infection by sprays of basic copper sulfate, captan, and tetrachloroisophthalonitrile and to a lesser extent with zineb and maneb. Sprays must be thorough and often during periods of high humidity.

PCNB (2.5 oz. 75% per cu. yd.) and thiram (8.4 oz. 50% per cu. yd.) mixed with methyl bromide fumigated soil before planting pansies severely stunted growth. Captan (2.9 oz. 50% per cu. yd.), tetrachloroisophthalonitrile (1.1 oz. 75% per cu. yd.) and 1,4-dichloro-2,5-dimethoxybenzene (0.35 oz. 65% per cu. yd.) did not cause stunting and gave some control of organisms attacking. PCNB caused stunting and retardation of snapdragons.

2. Camellia and Pyracantha. At Tifton, Ga., applications of phosphorus through soil or spraying of Camellia and Pyracantha had no significant effect upon dieback or berry rot (Glomerella cingulata);

3. Chrysanthemum. Infectivity associated with chrysanthemum stunt virus is only partially sedimented from crude sap when centrifuged at 50,000 rpm for 2.5 hrs in a Spinco No. 50 rotor. Infectivity can be concentrated by ethanol precipitation. Phenol-treated crude sap extracts and resuspended ethanol concentrates were as infectious as the untreated crude sap and ethanol-treated samples. Stunt infectivity is as stable in ethanol-precipitated extracts and phenol-extracted ethanol precipitates heated at 80°C for ten minutes as in untreated control preparations.

4. Holly. At Tifton, Ga., an undescribed Cylindrocladium sp. was found in addition to the usual Cylindrocladium scoparium attacking Ilex cornuta, I. japonica, and I. vomitoria. Control was obtained by polyram and tetrachloroisophthalonitrile sprays.

5. Lily.

a. Basal Rot. The root rot or root basal rot complex of lilies is being investigated. Isolations were made from emergence failures during commercial greenhouse forcing. These isolations yielded Cylindrocarpon radicicola, Fusarium oxysporum, Fusarium solani, Rhizoctonia, and one unidentified fungus. The root lesions nematode, Pratylenchus penetrans, was also isolated from roots. The role(s) of these organisms in the root rot complex is to be determined by future inoculation studies.

b. Virus. Lily viruses have been examined by electron microscopy. A normal length for particles present in the garden variety Enchantment could not be

established because of the heterogeneity of particle size in dip preparations. Long bundles of virus with an associated matrix or membranous coverings were observed.

6. Orchid.

a. Cymbidium Mosaic. A virus isolated from orchid was tentatively identified as a strain of cymbidium mosaic virus based on electron microscopy. The virus isolate infects Gomphrena globosa which was previously described in this country as a host specific for the orchid strain of tobacco mosaic virus.

b. Tobacco Mosaic. Five-year-old healthy orchid seedlings inoculated with the orchid strain of tobacco mosaic virus did not show color breaking when the plants flowered seven months after inoculations. The virus was not recovered from flowers or leaf tips of flowering leads.

7. Poinsettia. Three commercial varieties of poinsettia were inoculated with 24 clons of Thielaviopsis basicola from various hosts to determine pathogen virulence and varietal susceptibility to this fungus. Severe black root rot was obtained with 6-9 clons and those only when the soil was kept very wet following inoculation.

8. Phytotoxic Substances. Some major phytotoxic substances produced during the decomposition of plant residue in soil were identified as benzoic, phenylacetic, 3-phenylpropionic (hydrocinnamic) and 4-phenylbutyric acids. The effects of these compounds on the incidence of Thielaviopsis basicola root rot were studied. Chlamydospore germination in soil was not stimulated by any of the identified phytotoxins or by an ether extract of decomposed residue. Treatment of host roots with subtoxic concentrations of these materials, however, showed that disease severity was markedly increased by treatment with hydrocinnamic acid. Resistant varieties were also rendered susceptible to T. basicola following treatment with hydrocinnamic acid.

9. Stimulation of Sclerotia Germination. Sclerotia of Sclerotium rolfsii, a fungus pathogen of many ornamentals such as iris, lilies, and narcissus were shown to be stimulated to germinate and grow on field soil by volatile components of alfalfa hay. The antagonistic potential of exposed soil was increased both by the presence of S. rolfsii mycelium and the distillate. Following exposure to the distillates, sclerotia and mycelium were readily colonized by antagonistic or saprophytic organisms.

10. Rose. Fungicides folpet and maneb are effective fungicides against rose blackspot. Folpet reduced blackspot to a greater degree than maneb. The miticide, Morestan, was as effective for control of blackspot as the fungicide, maneb, when each was applied alone. The hybrid tea, "Charlotte Armstrong" appeared more resistant than "Red Radiance" to blackspot.

Soil application of fungicides captan, maneb, and DuPont 1991 for control of blackspot show various degrees of effectiveness. Captan and maneb are

effective only for a short period. DuPont 1991 is showing a longer lasting effect. Maneb and DuPont 1991 at higher concentrations bleach and burn the tips of leaves.

C. Culture and Physiology

1. Physiology of adventitious root formation. Adult Dioscorea composita plants were reverted to a juvenile condition of growth by forcing adventitious buds from rootstock sections. The rooting ability of stem-leaf cuttings from shoots derived from these buds was completely restored but was again lost as plants reverted to the adult stage--within a year. 2,4-Dinitrophenol and Compound 66-329 proved ineffective as root inducing agents with eight varieties of difficult-to-root trees and shrubs. Centrifuged cuttings of Camellia japonica showed an improved rooting response. Cuttings of C. reticulata were not improved by the same treatment.

2. Action of abscisic acid. Applications of RS-abscisic acid (ABA) to long-day plants--carnation, centaurea, and petunia--grown on long days delayed flowering as much as on plants grown on short days. The number of nodes to the flower was similar, whereas the lengths of the internodes were reduced by applications of ABA. The flowering of the short-day plants--chrysanthemum, marigold, and salvia--were unaffected by daily applications of ABA. Stem growths were inhibited without promoting flowering. Growth of the long-day plants--Japanese maple and American dogwood was suppressed while weigela and catalpa were unaffected from applications of ABA. ABA was not active in promoting leaf abscission of intact plants.

3. Anthocyanins - Measurement in Natural State - Rose. For the first time, instrumentation was available to study anthocyanins in their natural state. The anthocyanin in 'Better Times' rose presumably was present as a metal chelate. In-vitro studies with aluminum-anthocyanin-chelates indicated that extremely small changes in pH, particularly between 3.30 to 4.00, caused a shift in the λ_{max} from 515 to 555 nm. This resulted in a striking color change from red to blue. Absorption spectra from the in-vitro studies were similar to those obtained from intact tissue. These data obtained in cooperation with the Instrumentation Research Laboratory (MQ) offer an explanation of why roses blue as they age.

Anthocyanins - Isolation and Identification - Centaurea. Nine flavonoid compounds were isolated and identified from the stems and leaves of Centaurea cyanus cv. 'Blue Boy'. The co-pigment (bisflavone) associated with the blue pigment in the flowers, to date was not found in the leaves or stems. The anthocyanins from Centaurea cyanus cv. 'Red Boy' were isolated and identified. The co-pigment (bisflavone) found in the blue pigment from the cv. 'Blue Boy' was not present in the red varieties. 'Red Boy' cornflowers are red because the principal anthocyanidin is pelargonidin and this pigment is not capable of forming a stable co-pigment-metal-anthocyanin coordination complex as has been found in 'Blue Boy' cornflowers.

Hemerocallis and Poinsettia. Anthocyanins were isolated and identified from 5 cultivars of Hemerocallis. The relative distribution of these pigments was associated with the color of the flowers. To obtain purer red or violet cultivars, breeding lines should be selected that contain either cyanidin or delphinidin glycosides. Similar information was obtained for a number of poinsettia seedlings.

4. Chemical pruning - azaleas. Tested and evaluated new chemical pruning agents as substitutes for manual regulation of azalea plant growth. Studied effect of product formulation, plant size and condition of growth and cultivar on precision of response. Based on this original work, a commercial organization developed, registered, and is now selling a product for the chemical pruning of azaleas.

Five families of structures were identified: (1) petroleum products, (2) fatty acid esters, (3) fatty alcohols, (4) organic solvents, and (5) Propargyl compounds. The most effective structures contained a total of 11 carbons, were aliphatic with saturated carbon bonds. Fatty acid compounds with unsaturated carbon bonds or esterified in the middle of the carbon chain were much less active than those with saturated bonds or those esterified in the 1- or 2-positions. Triple bonding an esterifying 3 carbon radical (propargyl) made much more active compounds than ones with saturated esterifying radicals (propyl). Chrysanthemums, carnation, petunia, weigela, and marigold exhibited similar responses to the structural modifications of the five families of chemical pruning agents.

5. Bulbous iris. In cooperation with the Western Washington Research and Extension Center, the concept of degree-day as a maturity index for bulbous iris was tested to modify the handling procedures for iris forcing from November until May in the United States and for bulbs exported to Western Europe. Artificial heat curing at 90°F. of early harvested bulbs overcame blindness (failure to bloom) of bulbs forced for the earliest market. Continued high temperature storage delayed flowering even after vernalization. Delayed harvest of the bulbs delayed blooming perhaps because of accumulation of growth inhibitors. Reduced light intensity during winter forcing had more effect than reduction in natural photoperiod in causing bud blasting. Post-vernalization, pre-planting storage of iris bulbs at 65°F, for 5 to 10 days, improved the quality of the prized but over-vigorous cultivar, Prof. Blaauw, by reducing leaf length.

6. Controlled environments - seed germination. Demonstrated the importance of germinating seeds directly under controlled-environment conditions, rather than starting them under greenhouse conditions for the first 7 to 10 days. F₁ hybrid annuals (ageratum, marigold, and petunia) grown for 18 days from seed in a growth chamber at 400 ppm CO₂, 2500 ft-c. light, 85°/75° F. day/night temperature, 65% RH, and a 16-hour photoperiod and then moved to the greenhouse, were much larger and flowered much sooner than those grown initially in the greenhouse for the first 7 to 10 days. This improvement in cultural practice has not only resulted in greater acceleration of growth and earlier flowering but has made it possible to repeat germination conditions and

increase uniformity of experimental material, heretofore not possible. A millimeter difference in leaf growth at the 1 to 2 leaf stage has been found to telescope into large differences in subsequent growth of the plant.

Controlled environments - seedling growth

a. Light intensity and carbon dioxide concentration. By increasing the light intensity two-fold (2000 to 4000 ft.-c.) the carbon dioxide concentration five times (400 to 2000 ppm), and the day and night temperature 10°F. (75°/65°F. to 85°/75°F.), in experimental plant growth chambers, we have been able to produce lettuce (Grand Rapids) plants ready to eat in 15 days from seed, cucumber, tomato, and petunia plants with visible (macroscopic) flower buds in the same period of time. Ageratum and marigold plants had flower buds in 15 days. CO₂ enrichment resulted not only in precocious flowering but in extensive branching of the basal nodes.

b. Temperature and photoperiod. Petunia plants grown for 2 weeks at 85°/75°F. day/night temperature flowered earliest on a 16-hour photoperiod. Extending the photoperiod to 20 or 24 hours had little or no appreciable effect on subsequent flowering time in the greenhouse. When the day temperature was maintained at 75°F. during the light portion of the day, and the night temperature kept at 65°F., for 2 to 4 weeks, vegetative growth and flower development were progressively enhanced by increasing the photoperiod from 8 hours to 24 hours.

c. Nutrient level. Increased nutrient levels were required to realize the maximum benefit of CO₂-enriched atmospheres (2000 ppm), high temperature 85°F.), or elevated light levels (4000 ft.-c.). Vegetative growth and floral development were much greater at 85°/75°F. day/night temperature than at 75°/65°F. at CO₂-enriched atmospheres.

d. Age of plant. The optimum temperatures for growth of ageratum, petunia, marigold, cucumber, bean, and tomato tended to shift downward as the plants aged. Extremely high temperatures (95°-100°F.) were tolerated by cucumber and tomato during seedling emergence but these proved inhibitory for later growth. Daily shifts in growth were also noted in rapidly growing plants like marigold.

e. Light system. Comparative tests of petunias, marigold, and ageratum plants were made in cooperation with the Phyto-Engineering Laboratory of the Agricultural Engineering Research Division under a.c.-d.c.-operated lighting systems in growth chambers. These data indicate no substantial difference in either vegetative growth or floral development of plants grown under the two lighting systems.

7. Light responses of carnations. Carnations, as reported previously, are quantitative long-day plants. Earliest flowering occurs on the longest photoperiod and with a light source radiating equal red and far-red (incandescent filament lamps) light. Far-red light (emitted from photographic safety lamps) was as effective as equal red and far-red whereas red light

(emitted from cool white fluorescent lamps) was a very inefficient promoter of early flowering of carnations.

8. Chemical disbudding of chrysanthemums. Twenty-eight aromatic compounds, emulsified with a suitable surfactant were active in causing the abortion of partially initiated flowers of chrysanthemum. Surfactant type and concentration greatly altered the responsiveness of the plants to the aromatic compounds. Surfactants with near equal hydrophilic and lipophilic potentials produced stable emulsions which killed all flower buds. Surfactants with primarily hydrophilic potentials and augmented with high numbers of ethylene oxide caused the abortion of a very restricted age of flower buds. Sprays on the 14th and 15th short day caused the abortion of the side buds and the development of a normal terminal flower. These emulsions provided the maximum safety in dosage and treatment times of the disbudding agents.

9. Low temperature stratification of *Cornus* seed. At Cheyenne, Wyo., a pregermination exposure of *Cornus stolonifera* seed to 41°F. for 90 days promoted a high percentage of germination but the radicles did not develop. When the pregermination treatment consisted of 30 days of alternating 50°/77°F. followed by 60 days at 41°F., the radicles as well as the hypocotyls developed normally.

10. Easter lilies.

a. Controlled atmosphere storage. In cooperation with Market Quality Research Division, Easter lily bulbs of three cultivars tolerated a dynamic atmosphere at 100% nitrogen for 6 weeks at 50°F. and for 12 weeks at 32°F. without injury to the bulbs. Subsequent growth and flowering were delayed in comparison with plants from bulbs that were stored in air at the same temperatures. Reduction of the oxygen to 1% of the storage atmosphere delayed growth and flowering but to a lesser extent than when no oxygen was present. The modified atmospheres affected leaf number and lower leaf length more than the amount of reduction in flower number due to vernalization, indicating that the two expressions measure different aspects of senescence.

b. Replacement of storage requirement with light. Low intensity artificial light applied at stem emergence, or during the forcing accelerated flower initiation and blooming of Easter lilies and enhanced the plant quality by substituting for a portion of the preplanting vernalization requirement. Growing programs which combined vernalization and lighting were developed to regulate blooming time and plant use with the four principal commercial Easter lily cultivars.

c. Forcing - Tifton, Ga. Georgia Easter lily plants in pots were placed under lights either before or after moving into the greenhouse to further determine the effect of light replacing cold requirements for the bulbs. Lighting for 4 hours at the beginning of the dark period was as beneficial as lighting in the middle of the period. One hour lighting was insufficient whereas continuous lighting overstimulated stem elongation. Development of several leaves was necessary before lighting to obtain response. Bulbs

lighted before sprouting did not respond. Light from fluorescent lamps was as effective as light from incandescent filament lamps.

11. Photoperiod responses of woody plants. The critical photoperiod for the transition of ornamental woody plants from vegetative growth to flowering was 14 hours when the plants were grown with night temperatures of 65°F. Photoperiods 14 hours or longer promoted rapid growth and flowering of abelia and weigela; photoperiods shorter than the critical limited growth and suppressed flowering. Photoperiods shorter than 14 hours retarded growth and promoted flowering of Bougainvillea and blue-mist spirea. Most rapid flowering occurred on 10- and 12-hour photoperiods. The flowering time was later and the number of flowers was less on plants grown on 8- than on 10- and 12-hour photoperiods. The light source used for the photoperiod extensions was incandescent-filament lamps which emit equal red and far-red light. Daylength extensions with far-red light induced flowering responses similar to equal red and far-red light but promoted greater stem elongation and paler leaf color than observed on plants exposed to incandescent lamps. Daylength extensions with red light (cool white fluorescent) were inefficient in promoting stem elongation but induced the development of dark green foliage.

D. Systematic Biology

Herbarium and taxonomic research. An addition of 25,000 specimens to the herbarium research collections has resulted from domestic and foreign explorations and from exchange with cooperating agencies and institutions. These resources are being used in the preparation of international cultivar checklists for *Ilex*, *Viburnum*, and *Pyracantha*. Studies are continuing on the systematics of *Cruciferae*, *Sambucus*, *Malus*, *Ilex*, and *Viburnum*.

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SHADE AND ORNAMENTAL TREES, FARM WINDBREAKS,
BREEDING, DISEASES, AND CULTURE

Crops Research Division, ARS

(RPA 905 - TREES TO ENHANCE RURAL AND URBAN ENVIRONMENT)

USDA and Cooperative Program

Location of intramural work	Commodity	Scientist man-years FY 1968
Maryland (Beltsville)	Shade trees	0.2
District of Columbia	Shade trees	2.5
Georgia	Shade trees	-
Ohio	Shade trees	2.8
North Dakota	Farm windbreaks	1.0
Wyoming	Farm windbreaks	1.2
	Total	7.7

No extramural support.

Problems and Objectives

Shade tree diseases of unknown cause are present in several regions of the U. S. Lack of practical, effective control measures of many known diseases limits the number of species that can be used in rural and urban areas. The Dutch elm disease continues to spread westward. Concern over the use of pesticides has increased the demand and need for new methods of controlling Dutch elm and other diseases. More information is needed on the culture and maintenance of trees and on improving the effectiveness of farm windbreaks.

Major objective of the research are to:

1. Develop improved methods of control of Dutch elm and other tree diseases by genetical, biological, and chemical means.
2. Develop basic information on nature of disease resistance and susceptibility.
3. Improve cultural practices for shade trees and trees in farm windbreaks.
4. Determine the effect of windbreaks on nearby crops.

Progress - USDA and Cooperative Programs

A. Breeding

1. Elm. Chromosome counts and interspecific crosses were made between fall-flowering elm species. Ulmus americana, and related U. floridana, were confirmed as tetraploids. Five other species, counted for the first time, are diploids.
2. Magnolia. Polyploid progenies resulting from interspecific hybridization in magnolia indicate wide possibilities for development of cultivars with specific landscape characteristics. Eight selections of M. liliflora x stellata parentage have been released. All are multiple-stemmed, rounded or conical, 6-10 ft. deciduous shrubs of erect growth habit. A frost evading character has evolved in that all selections flower later than the parental forms of M. stellata.
3. Sycamore. Chromosome counts of Platanus occidentalis, orientalis, and racemosa indicated that all are diploids with a complement of $2n=42$.

B. Diseases

1. Dutch elm disease. Bacillus polymyxa is being studied as a biological control agent for Dutch elm disease and Verticillium wilt of elms. The bacterium is inhibitory to both Ceratocystis ulmi and Verticillium albo-atrum in vitro but the inhibitor appears to be other than the low molecular weight acids reported by other workers.

Relative turgidity was found to be unsuitable as a technique for estimating water stress in Ulmus species because of the marginal absorption of water through cut leaf surfaces. In addition, a potentially significant source of error was discovered in measurements of leaf water potential using the vapor equilibration technique.

Hard-to-root elm species now can be rooted more successfully. Stem cuttings of species of elms known to be resistant to Dutch elm disease rooted more readily when they were first disinfected by flaming them briefly. Only 28 percent of untreated cuttings rooted while 56 percent of the flamed cuttings rooted. Tests showed that Fusarium solani caused stem and root rot of the cuttings and that its damage could be reduced by the flaming technique.

C. Culture.

1. Windbreak thinning and root pruning. Two recent severe blizzards have demonstrated the need for leaving more room or planting trees in greater depth to prevent snow from blocking farm yards and suffocating livestock seeking shelter. Thinning and root-pruning of field windbreaks to reduce root competition to the crop were started in 1967. In thinning, every other tree was removed to double the open space between trees. Winter snowfall was light and spring thaws took place much earlier than normal. Land adjacent to the thinned sections was ready for farming 30 days earlier than the check unthinned sections.

Tree roots 12 feet from the tree were cut to a depth of 24 inches. Excavation in the cut areas 3 months afterwards showed roots of 7-year-old Siberian elm to have callused on the tree side and new roots coming out from adventitious buds immediately behind the callus. The new roots varied in number but many had more than 40 new roots, some of which had grown to a length of 32 inches in the 3-month period. Shallow roots on the field side sent out new shoots aboveground that leafed out and maintained the cut roots in a thriving condition. Cut roots at greater depths were generally dead.

2. Hardy tree species for windbreaks. The tree and shrub testing program shows the following species can be added to the recommended hardy list: Caragana microphylla, Cladrastis amurensis, Ulmus japonica, Syringia amurensis, and Larix sibirica for windbreak purposes and Caryopteris mongolensis and Potentilla sp., two attractive long-flowering shrubs, for beautification purposes.

3. Wind erosion. High velocity eroding winds occur from all directions. The most damaging ones originate in the northwest. Velocities of 30 to 50 miles per hour can be expected from that direction every month of the year. Velocities of 40 to 50 miles per hour can be expected from October through July. This is a period when fallow, sugar beets, and potato lands are without protective cover during 8 of the 12 months. Winds from the south-east are the second most damaging ones and closely approximate those from

the northwest. High velocity winds from the southeast, northeast, and southwest can be expected during March, April, and May when cultivated land has little protective cover.

4. Leaching of nutrients. Evidence was found on sandy soils that snow-drifts can cause severe leaching of soil nutrients. This was reflected in crop color and apparent yield as contrasted with the crop beyond the drift area and also in an extension of the drift area beyond the end of the tree row. Soil moisture was more plentiful in the top 4 feet of the snowdrift area.

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WEED AND NEMATODE CONTROL

Crops Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968			: Total
	: Research Problem Area :			
	: 205	: 206	: 906	
Maryland (Beltsville)	: 1.0	: 1.0		: 2.0
Arizona	: 0.5			: 0.5
Florida	: 2.0			: 2.0
Georgia	: 1.5	: 1.0	: 0.5	: 3.0
Iowa	: 0.2			: 0.2
Louisiana	: 0.2			: 0.2
New Jersey		: 1.0		: 1.0
North Carolina	: 0.2			: 0.2
South Carolina	: 2.0			: 2.0
Texas	: 0.4	: 1.0		: 1.4
Utah	: 0.5			: 0.5
Total	: 8.5	: 4.0	: 0.5	: 13.0

Intramural program is supplemented by extramural support ^{1/} representing (a) 4.8 SMYs at State Agricultural Experiment Stations ^{1/}, (b) 1.1 SMYs at other U.S. institutions ^{2/}, and (c) P.L. 480 funds in 5 countries representing 127,415 U.S. dollars equivalent.

1/ RPA 205, 1.5 SMY; RPA 206, 3.3 SMY

2/ RPA 206, 1.1 SMY

Problems and Objectives

Effective and safe weed control is essential to the continued production of sufficient food, feed, and fiber to meet the increased requirements of our rapidly growing population. All methods of control--cultural, mechanical, biological, and chemical--must be employed to minimize crop losses due to weeds. For the foreseeable future, however, herbicide control measures, alone or in combination with other methods, offer the greatest promise for economically and effectively controlling problem weeds. In addition to effectiveness, herbicide measures must be rigidly evaluated for their safety with respect to lack of contamination of harvested crops and environment, and absence of harmful persistence in soils at levels which affect succeeding crops.

Weeds hinder the complete mechanized production of many horticultural crops and the resulting improvement in efficiency. Estimated average annual losses in yield and quality of horticultural crops due to weeds for the decade ending in 1960 was more than \$250 million. In addition, an average of more than \$300 million was spent for control measures each year.

Nematodes attack all crop plants, and cause varying damage and crop losses, but losses are estimated at nearly 1-billion dollars annually. Most plant-parasitic nematodes infect roots and other underground parts of plants, but some attack bulbs, stems, leaves, and flowers. Damage initiated by nematodes is often extended by bacteria, fungi, and viruses. Damage can be reduced by use of varieties resistant to nematodes, but only a relatively few are available. Development of resistant varieties is time-consuming and does not completely protect the crop because multiple nematode resistance is difficult to attain and is lacking in all varieties thus far developed. Crop rotations have been devised to reduce some of our more important nematode problems, but rotations rarely fit modern management practices, or may be uneconomical. While naturally-occurring biological agents undoubtedly have a great influence on nematode populations, manipulation and use of these principles for economic control is not practical.

Major objectives of the research are to:

1. Discover new principles and develop new and improved chemical, cultural, biological, mechanical, and combination methods of controlling weeds in plantings of horticultural crops.
2. Determine sites and mechanism of action of herbicides and the basis for their selective action in weed and crop species.

3. Develop proper methods of analysis for herbicides, metabolites and degradation products in plants and determine the effects of environment on the degradation of herbicides applied to all types of crops.
4. Determine the effects of climate, cultural practices, and soil composition on herbicide performance, persistence, and selectivity.
5. Determine factors which influence the germination, growth, and development of major weeds and to evaluate various stages of growth for susceptibility to control measures.
6. Study the identification and distribution of nematodes.
7. Investigate the physiological relations of nematodes to plants, including nature of resistance.
8. Evaluate susceptibility and resistance of crop plants, and factors determining or modifying pathogenicity.
9. Determine interrelationship of nematodes and plant diseases.
10. Develop cultural and biological control practices, as related to crops, soil, and environmental factors, that will reduce nematode losses.
11. Improve chemical control practices and determine the toxicity of nematocides to nematodes and crop plants.

Progress - USDA and Cooperative Program

RPA 206 - CONTROL OF WEEDS AND OTHER HAZARDS
TO FRUIT AND VEGETABLE CROPS

A. Vegetables

Surface, preemergence applications of atrazine prevented fibrous brace root formation in sweet corn and reduced yields about 30 percent. Cultivation of soil over the brace root area during early vegetative growth prevented this effect.

Subsurface chisel placement of vernolate in the soil controlled more than 90 percent of the nutsedge present in plantings of southern peas. Vernolate applied after peas reached the 4 to 6 leaf stage did not reduce yield or quality of the crop. Treatments applied at earlier growth stages caused severe injury. Among several herbicides studied for use in mustard and turnip green plantings, DCPA and trifluralin were most effective and best tolerated by the crops. Because of its persistence in the soil, trifluralin presents a problem in rotation practices.

In furrow-irrigation, several herbicide families controlled weeds most efficiently when incorporated uniformly into soil; soil surface-applied herbicides required rain for activation and could be moved by high winds. The most efficient depth of mechanical soil incorporation depended on characteristics of the specific herbicide and climatic conditions after treatment. Deeper incorporation required more selective herbicides or delayed vegetable plantings for selectivity. Increased rates of herbicidal application and depth of incorporation resulted in longer persistence in soil. Volatile carbamates often persisted only one month, whereas, less volatile compounds persisted five to 11 months in field soils. Soil-incorporated carbamate herbicides were generally deactivated in the greatest depth of incorporation and persisted the longest near the surface of furrow-irrigated soils. Several soil-persistent herbicides were sufficiently selective with soil incorporation in plantings of certain vegetables, namely: trifluralin in carrots and cabbage; N-isopropyl-2-chloroacetanilide (CP-31393) in onions; bensulide in cantaloupes, watermelon, cabbage, carrots, lettuce, and tomatoes; and benefin in lettuce.

The quality of raw tomatoes was unaffected by herbicidally effective treatments of diphenamid, amiben, or DCPA. Maturation of tomato fruits was hastened by herbicide treatment. The composition of the processed product was unaffected by herbicide treatments.

The levels of 17 nutrient elements in the leaves of potatoes were unaffected by herbicidally effective treatments of EPTC or DNBP applied before emergence of the crop.

B. Fruits

A seven-year study of the effects of repeated annual applications of several herbicides in blueberry plantings showed that growth, yield, and quality of the crop were not reduced by simazine or diuron. Herbicidal effectiveness of diuron treatment increased as treatments were continued, whereas, effectiveness of simazine decreased. Simazine-tolerant weed strains were evident. Control of weeds in peaches conducted over a seven-year period revealed that this crop is a poor competitor with weeds, even low growing grasses. Simazine used repeatedly did not reduce growth rate,

yield, or quality of the crop. Simazine-tolerant weed strains developed. Dichlobenil controls bracken fern in cranberries without reducing growth, yield, or quality of the crop.

C. Ornamentals

Yews and Japanese maple seedlings were found tolerant to four annual applications of CIPC, DNBP, DCPA, and trifluralin used at twice the usual weedkilling dosage. Combinations of two of these herbicides at less than the usual individual dosages may prove practical for broad spectrum weed control in these crops.

A new method of applying herbicides impregnated in cloth is proving effective as a means of improving accuracy and convenience in the use of herbicides in ornamental plantings and in home-garden vegetable plantings. Three carbamate herbicides, 4 symmetrical triazines, and dichlobenil are proving effective as soil treatments to control mugwort (Artemisia vulgaris L.).

RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

A. Fruit

1. Citrus. Control of the citrus nematode on bearing trees with the nematocide DBCP has resulted in substantial yield increases for the first time in Florida. Applications of emulsifiable DBCP through sprinkler irrigation has been improved, and a water pressure-injection system for applying nematocides to established trees has been developed. Also, bare-root dips of nursery stock with organophosphate nematocides has given practical control of burrowing and citrus-root nematodes. No chemical phytotoxicity was evident. Bare-root dips have recently been incorporated into regulatory programs to rid nursery rootstock of plant-parasitic nematodes in Florida. In Arizona, a 9-year study of citrus nematode control with DBCP in irrigation water, shows that citrus groves treated with 2-gallons per acre of DBCP allows new normal citrus growth and gives good nematode control for 2 years, with accompanying high yield increases. After 2 years, retreatment is necessary, but the cost is nominal.

2. Peaches. In Georgia 3 species of root-lesion nematodes (Pratylenchus vulnus, P. brachyurus, and P. zeae) occurred in large numbers but in varying proportions. Studies of individual trees revealed that tree decline was associated with frequency of occurrence of P. vulnus. The other species, though frequently found in peach orchards, were not contributing significantly to short life. Several new nematocides control both root-knot and lesion nematodes on peaches, and thereby allow vigorous growth of first and second-year seedlings.

B. Vegetables

In South Carolina, plastic growth pouches are used for preliminary screening of plants grown from seed for nematode resistance. Success is dependent upon controlled temperature regimes. Small temperature differences alter resistance reactions in experimental work. Bushbeans (PI-165426) were found resistant to the root-knot nematode (Meloidogyne incognita). Germ plasm from several wild melons was found with resistance to root-knot nematode. Resistance in the wild melon species is expressed through delayed development of nematode larvae.

In Utah, roots of 18 varieties of potato were galled by the northern root-knot nematode (Meloidogyne hapla). There was noticeable difference in the severity of galling. Breeding lines also differed in number of egg masses produced, nematodes per egg mass, and nematodes produced per unit weight of root. Nematodes produced per gram of root varied from 66 per gram on 'Monono' to approximately 46,000 per gram on 'Bounty'. These data indicate that existing potato varieties have greatly different characteristics in increasing soil populations of nematodes.

In Louisiana, control of reniform nematode and highest yields and best grades of sweetpotatoes were realized from soil treatments with Temik, Dasanit, and Mocap. These chemicals perform better than chlorinated hydrocarbons such as DD. The best treatment, Temik, increased yields of US No. 1 sweetpotatoes by 133 bushels per acre.

In Georgia, a mixture of specific biocides (nematocides, herbicides, and fungicides) were compared with wide-range soil fumigants for control of nematodes, weeds, and soil fungi. Both specific nematocides and wide-range soil fumigants gave significant control of root-knot, but this control was not adequate for tomato transplant production.

Mocap gave best root-knot control of several nematocides tested. The wide-range soil fumigants, Vorlex, Darco, and MTBG gave measurable weed control. All treatments involving the herbicide Pebulate, and MTBG, gave excellent weed control. Tomato transplant growth was best when good weed and nematode control was obtained. The experiment did not indicate that soil fungicides were necessary for tomato transplant production in south Georgia. Control of root-knot nematodes on Yellow Crookneck squash, Emerald okra, Thaxter bean, and Cream-40 cowpeas indicated that organophosphate nematocides gave good nematode control and yield increases comparable to results obtained with proprietary soil fumigants, such as EDB. When root-knot was controlled, yield increases of more than 5-tons per acre of squash, 12-tons per acre of okra, 3-tons per acre of lima beans, and 1.2-tons per acre of southern peas were obtained.

Long-term rotation studies of cultivated crops and sod base rotations continue to show that proper selection of rotation sequences can prevent buildup of damaging populations of nematodes in Georgia. Such crops as Hairy Indigo, beggarweed, Crotalaria, and marigolds reduce numbers of both ectoparasitic nematodes (such as sting and stubby-root) and endoparasites (such as lesion and root-knot). Many grasses such as Coastal bermuda and fescue control root-knot nematodes, but greatly increase damaging populations of ectoparasitic nematodes. Other grasses such as millet and sudangrass increase root-knot and certain ectoparasitic nematodes.

RPA 906 - CULTURE AND PROTECTION OF
ORNAMENTALS AND TURF

A. Ornamentals

Excellent control of root-knot nematodes was obtained on Dwarf Japanese holly and Japanese boxwood with Dasanit and Mocap as drenches. These chemicals gave almost complete control of root-knot nematodes in Georgia.

Nursery groundbeds in Florida, containing Philodendron and Dffenbachia, were drenched with Dasanit, Zinophos, Mocap, and Furadan as soil drenches from 100 to 800 ppm of the chemical. All chemicals gave good control of root-knot nematode after 6-weeks. All plants grew normally and were apparently healthy.

In greenhouse studies combined inoculations of chrysanthemums with Meloidogyne hapla and Fusarium oxysporum increases the severity of wilt symptoms on the Yellow Delaware cultivar in Georgia; the wilt-resistant Yellow Iceburg cultivar failed to show wilt symptoms after 3-months, even when inoculated with nematodes. The nematodes completed their life cycle in roots of both cultivars, but the nematodes alone did not appreciably affect plant growth.

B. Turf

The sting nematode (Belonolaimus longicaudatus), the pseudo-root-knot nematode (Hypsoperine graminis), and the stubby-root nematode (Trichodorus christiei) cause great damage to turf grasses. In Georgia tests, several chemicals controlled these nematodes and restored turf to vigorous growth. Best overall performance was given by Nemagon, Zinophos, Thimet, Dasanit, and Mocap. Furadan and Temik gave fair nematode control but were less effective than the organophosphates as post-planting treatments on turf.

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RPA 906 - Culture and Protection of Ornamentals and TurfOrnamentals

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VEGETABLE INSECTS

Entomology Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years FY 1968			Total	
	Research Problem Area				
	204	205	701		
Arizona	2.0			2.0	
California	4.0			4.0	
Georgia	0.5			0.5	
Idaho	0.1	0.1		0.2	
Indiana	1.0			1.0	
Maine	0.6	0.4		1.0	
Maryland (Beltsville)	3.2	0.1	0.8	4.1	
Oregon	0.3	0.3		0.6	
South Carolina	5.0			5.0	
Washington	2.9	0.2	1.7	4.8	
Total	19.6	1.1	2.5	23.2	

Intramural program is supplemented by extramural support^{1/}, representing
 (a) 0.6 SMY's at State Agricultural Experiment Stations^{1/}, (b) 1.6 SMY's
 at other U.S. institutions^{2/}, and (c) PL 480 funds in 0 countries.

1/ RPA 204 - 0.6; RPA 701 - 0.0

2/ RPA 204 - 0.8; RPA 205 - 0.8; RPA 701 - 0.0

Problems and Objectives

Vegetable crops are subject to heavy losses by insects through direct feeding damage and through transmission of plant viruses. Current grower practices involve the use of insecticides as the principal means of controlling insect pests. Attendant problems in the use of insecticides are the presence of undesirable residues on the marketable plant parts, environmental pollution, insect resistance to chemicals, toxic effect on beneficial insects, and recurring costs of insecticide treatments. Consequently, alternate methods for control of vegetable insect pests are urgently needed. Annual losses to insects are estimated at over \$185 million.

Major objectives of the research are to develop methods for control of insect pests by means of:

1. New, selective, nonpersistent insecticides that will minimize or avoid residues.
2. New approaches such as sterility, attractants, biotic agents, and bioenvironmental methods.
3. Insect resistant germ plasm in vegetable crops.
4. Integration of various of the above methods.

Progress - USDA and Cooperative Programs

RPA 204 - CONTROL OF INSECT PESTS

A. Basic Biology, Physiology, and Nutrition (2.0 SMY)

1. Cabbage

a. Cabbage looper. At Riverside, Calif., cabbage loopers were reared from egg to adult under various constant and cyclic temperatures. At the constant temperatures of 60, 70, and 80° F, the mean days required from egg to adults were 73, 41.7, and 21.0, respectively. At the cyclic temperatures of 40-50-60, 50-60-70, and 60-70-80° F, the developmental periods from egg to adult were greater than 134, 71, and 37 days, respectively. Under outdoor conditions during the same period, from early March to mid-May, the mean developmental period was 69.3 days.

A black strain of cabbage looper moths was started at Riverside from a single female mutant found in the laboratory culture. When this female was mated to a normal male, both male and female progeny segregated into 1:1 ratios for black and normal color. Additional work to determine the genetics of the mutant is underway.

Injection of cabbage looper pupae with nuclear polyhedrosis virus at Riverside showed that as pupal age advanced higher virus titers were required to prevent emergence of adult moths. Moths emerging from pupae

were frequently deformed, lacked the dark pigmentation of normal moths, and were shorter lived. When injected as adult moths, longevity, mating, and oviposition were not affected but egg viability was reduced.

Purified polyhedra from the cabbage looper and alfalfa looper fed to their own and reciprocal hosts at Riverside showed that the alfalfa looper virus was infectious to both hosts while the cabbage looper virus appeared more infective to its own host. The virus rods in polyhedra isolated from the cabbage looper are occluded singly in the polyhedral matrix while those from the alfalfa looper are occluded in bundles.

In laboratory studies on the effect of a recently discovered cytoplasmic polyhedrosis virus on various developmental stages of the cabbage looper, only 23 and 26% of male and female pupae, respectively, were of normal weight. Moth deformities increased as pupal weight decreased. Preliminary tests indicated that the virus is transmitted on the egg surface and that infection in adult females tends to reduce oviposition. Laboratory studies showed that polyhedra were inactivated by temperatures 70° C or higher for at least 8 hours and by alkaline solutions ($Na_2 CO_3$) of more than 0.01 M for 10 minutes. Formaldehyde in the artificial diet lowered the activity of polyhedra. An aqueous suspension of polyhedra remained infective for 1 year under refrigeration.

2. Sweet Corn

a. Corn earworm. At Charleston, S.C., the incorporation of gibberellic acid in a semisynthetic diet at levels up to 5 ppm had no measurable effect on pupation success, pupal weights, or adult emergence. The modified diet was fed to the larvae throughout their entire development period.

Fifteen light traps were placed at levels varying from 25 to 1,050 feet on a 1,250-foot television tower at Pelham, Ga. The traps were designed so that any moth attracted to the trap had to be flying as high or higher than the trap. Weekly records indicate that Heliothis zea frequently fly at the 1,050-foot level. During the week of peak H. zea flight of August, over 90% of the total insect catch at the 1,050-foot level was H. zea.

Surveys conducted on St. Croix, V.I., during 1968 revealed that population levels of the corn earworm, fall armyworm, and sugarcane borer were sufficiently high to allow experimentation with suppression and eradication programs. Corn earworm moths tagged with P-32 and recaptured in virgin female traps demonstrated that most of the insects were concentrated in the vicinity of six corn fields on the Island; however, collections from 256 light traps scattered over the Island revealed the ability of the moths to range over the entire 84-square-mile landmass. The total natural corn earworm population during the month of radioactive captures on the Island was estimated at 9,152 males, or 109 males per square mile. Based on these results, attempts will be made on St. Croix

to eradicate the corn earworm by the sterile male release method.

3. Cucurbits

a. Banded cucumber beetle. At Charleston, S.C., an almost black, melanistic strain of the banded cucumber beetle was selected from several field-collected specimens. Preliminary data indicate that the dark color is controlled by a single recessive gene.

The addition of 50 ppm of cucurbitacin E (Semi-purified extract from bitter fruited watermelon) to the standard semisynthetic diet, increased the longevity of banded cucumber beetles and the number of eggs per female. The beneficial effect apparently was not due to the known feeding stimulant activity of the cucurbitacin since there was no significant difference in the consumption of the diet with or without the additive.

4. Strawberries

a. Spider mites. At Riverside, Calif., biweekly surveys from October 31, 1967, through May 14, 1968, to determine population fluctuations of the two-spotted spider mite showed that the populations declined to a low of less than 1 per leaflet on December 26, and reached a peak of 272 per leaflet on May 14 when the survey was terminated.

5. Potatoes

a. Aphid predators and parasites. Tests at Presque Isle, Me., showed that some kinds of diapause in the 7-spotted ladybird can be broken without harmful effects to ovipositing females by exposing the adult female to a continuous source of low-intensity incandescent light. However, inadequate food in the larval stage resulted in diapause in the adult female which incandescent light did not break. Some but not all of this kind of diapause disappeared from beetles that overwintered in hibernation cages over grassland out-of-doors. Winter survival of the adult beetles in these cages was influenced by age and condition of beetles when placed in the hibernation cages. Well-fed beetles maturing in early to midsummer survived better than those fed insufficiently for a period of 2 or 3 weeks before being placed in the cages. Winter survival of beetles maturing in September was influenced greatly by their age and by abundance of food in the larval stage and after maturation before being placed in the cages. There was no winter survival among specimens placed in cages as newly emerged adults, little survival when the adults matured from inadequately fed larvae (1 - 10%), and variable survival (16 - 53%) of adults moderately to well fed as larvae and fed for varying periods as adults. An average of 750 green peach aphids of all sizes was required for a newly hatched larva to develop to the pupal stage. The numbers required were 6.4, 15.9, 122.8, and 604.9 for development of the first to fourth instars, inclusive.

Marked improvements in oviposition of 7-spotted ladybird beetles resulted from improvement in techniques of mass rearing the larvae and in the storage, handling, and care of the adults. Both the numbers of egg clusters and eggs per cluster deposited by individual female beetles were larger in 1968 than in 1967. Progressive reduction in egg viability with age of females remained a problem.

Introduced from northern India, Aphidius smithi, a braconid parasite of the pea aphid has become established at Yakima, Wash., and other northern locations. Its unusual hardiness was demonstrated when parasites were captured in flight at Yakima during December and January when the air temperature was 4.4° C.

b. Green peach aphid. A mechanical trap utilizing yellow baffle plates for impaction surfaces and bottles of a dilute formaldehyde preservative was developed at Yakima, Wash., for determining hourly, as well as longer, periods of flight activity of the green peach aphid. Most flights occurred during daylight and twilight hours of the day; temperature was a lesser deterrent than wind to aphid flight.

c. Wireworms. In Autumn, sampling studies in 22 fields on 17 farms in Charleston County, S.C., wireworm populations in the various fields ranged from 0 to 5.0 larvae per square foot with an average of 1.6. The relative abundance of the various species was as follows: Conoderus falli, 69%; Glyphonyx sp., 15%; Conoderus amplicollis, 10%; and Conoderus vespertinus, 3%. One Melanotus communis and two undetermined elaterid larvae were found. Light trap studies at Charleston in and around an isolated corn field showed that although a few southern potato wireworm adults penetrated as much as 2 miles into woodlands, 83% of the adult population remained in the cultivated fields.

6. Cross Commodities

a. Cabbage looper. Population counts made at Charleston, S.C., during the spring season, on randomized field plots of lettuce and cabbage showed that 96% of the larvae recorded were on the cabbage. Very few looper eggs were observed on the lettuce foliage indicating that cabbage was preferred for oviposition.

b. Green peach aphid. At Purdue University, studies under a grant to determine the influence of electromagnetic energy on the green peach aphid revealed the following: (1) nymphs were more responsive to shorter wave lengths of monochromatic light ranging from 450 to 650 mu than were adults; (2) adult aphids ranging from 1 to 19 days in age responded similarly regardless of age except that older aphids tended to respond less to short wave lengths and more to longer wave lengths; and (3) the preconditioning effects of exposure to alternate light and dark did not affect their response to monochromatic light.

c. Spider mites. At Pennsylvania State University under a grant, a method was developed for rearing spider mites on homogenates of bean which will be used in the study of nutritional factors affecting spider mite reproduction and longevity. In a comparison of methods for separation of amino acids and proteins, thin layer chromatographic techniques were superior to alternate methods including cellulose acetate strip electrophoresis.

B. Insecticidal and Cultural Control (2.2 SMY)

1. Beans

a. Mexican bean beetle. In a field plot test at Charleston, S.C., five weekly spray applications of Gardona, Dursban, and malathion reduced larval populations by 99, 98, and 94%, respectively. A spray containing a 1-400 dilution of Pyrocide (1.4% pyrethrum) was ineffective.

Of 21 pesticides screened for toxicity to the Mexican bean beetle at Beltsville, Md., Gardona, Azodrin, azinphosmethyl, carbaryl, carbophenothion, diazinon, dimethoate, endosulfan, and parathion gave good control as 1- and 7-day residues. Other materials showed high toxicity by 1-day residues and poor control by 7-day residues.

b. Western bean cutworm. DDT was the most effective of several materials applied to bean fields by ground and air equipment in the Twin Falls and Rupert, Idaho, areas for control of western bean cutworm. Trichlorfon also gave promising control.

2. Cabbage

a. Cabbage looper. Nine of 57 experimental compounds compared in laboratory tests in Charleston, S.C., showed a high order of toxicity. In field tests during the 1967 fall season, UC-34096, Dursban, and Stauffer N-4446 each at 1 lb/acre provided good plant protection against light populations of the cabbage looper and the fall armyworm. A low volume spray of naled failed to provide adequate cabbage looper control on cabbage. In 1968 spring season tests, Ortho 9006, SD-15289, Azodrin, and ENT-27325 were the most effective of the compounds tested.

3. Cucurbits

a. Banded cucumber beetle. Six of 80 experimental compounds screened in the laboratory in Charleston showed promise for soil applications to control larvae.

b. Greenhouse whitefly. At Beltsville, Md., 3 applications of Azodrin, azinphosmethyl, parathion, or naled were the most effective of 8 spray schedules in reducing whitefly populations on greenhouse cucumbers. Single applications of the same materials were the most effective of

4 additional compounds. In tests with soil systemics, Union Carbide UC-21149 and dimethoate were the most effective in reducing whitefly populations.

In tests of sprays or aerosols, azinphosmethyl, Azodrin, and parathion were highly effective against whitefly nymphs up to 6 days old and dimethoate against nymphs up to 4 days old. Azinphosmethyl and Azodrin also killed a high percentage of pupae. Residual toxicity of azinphosmethyl and Azodrin gave complete kills of nymphs hatching from eggs of all ages up to 10 days after treatment whereas parathion and dimethoate killed nymphs up to 8 days after treatment. In aerosols, parathion and tepp were the most toxic of several materials to nymphs up to 6 days old but lacked residual toxicity against eggs.

4. Peas

a. Pea aphid. Soil applications of UC-21149 to alfalfa, the overwintering host of the pea aphid suppressed aphid populations through three plant growth cycles in the presence of the braconid parasite, Aphidius smithi, in eastern Washington. Neither UC-21149 nor parasites alone was as effective for aphid control.

5. Potatoes

a. Aphids. At Presque Isle, Me., both disulfoton and UC-21149 gave satisfactory all-season control of aphids on Katahdin potatoes. When applied as foliar sprays at 0.2 lb active ingredient/A, parathion was somewhat more effective than endosulfan; however, 3 applications of each were required to hold down aphid populations to predesignated low levels.

At Presque Isle, a slight but highly significant early season reduction in aphid population resulted from mulching Katahdin potatoes with aluminum foil. The difference was not significant when only 50 to 95% of the soil was covered with the aluminum. The reduction soon disappeared, presumably because the potato foliage expanded to cover the aluminum and eliminate its repellent effect upon flying aphids. Throughout the remainder of summer the aphid populations were about the same in mulched and unmulched plots and at harvest tuber yields were not affected by treatment.

At Presque Isle, no mortality occurred during 1-week periods among fox-glove aphids caged on new foliage of 1-week-old Katahdin potato plants grown from daughter tubers harvested from plants grown in plots side-dressed with disulfoton or in plots receiving planting furrow treatments of UC-21149. However, there appeared to be a depressive effect upon reproductive rate of the aphid from the UC-21149.

Katahdin potato tubers grown in untreated soil at Presque Isle in 1966 were planted in 1967 in potted soil into which was mixed disulfoton,

UC-21149 or Bay-68138. After the plants emerged, foxglove aphids were caged weekly for 4 weeks on new leaves of the growing plants. All treatments proved highly toxic to the aphid during the 4-week test period. All adult aphids died before depositing nymphs.

In studies at Yakima, Wash., approximately 5,500 peach trees, representing the principal overwintering source of the green peach aphid within a 275 mi² area in the Columbia Basin of eastern Washington were sprayed with an insecticide in the spring for 3 consecutive years to prevent migration of the aphid to potatoes and other susceptible crops. In 1967, the green peach aphid population on potatoes on the leeward side of the sprayed area during the season was 97% less than in 1965 when the trees were not sprayed.

b. Wireworms. In 3 years' tests at Yakima, Wash., Dyfonate was as effective as diazinon or parathion as a soil treatment for the control of wireworms.

In field plot tests at Charleston, S.C., Bay-77488, Bay-78182, Dursban, and carbofuran were equal to parathion in reducing larval populations of the southern potato wireworm in the soil.

6. Sweet Corn

a. Corn earworm and fall armyworm. At Tifton, Ga., Gardona was shown to be extremely toxic to corn earworm moths. Sugar water solutions containing varying rates of Gardona gave up to 100% mortality in 24 hours when as little as one microgram was fed per moth. Dosages greater than 10 micrograms per moth gave 100% mortality in all replications. A dosage of 0.5 microgram per moth produced 80% mortality in 24 hours.

In laboratory bioassays of new experimental materials against fall armyworm larvae, seven gave 100% mortality 24 hours after exposure to leaf discs dipped in a solution containing one ounce active ingredient per 25 gallons of water.

In field evaluations, the following low volume formulations and new materials gave effective control of corn earworm and fall armyworm: Endosulfan-malathion, DDT-malathion, Gardona, malathion, Azodrin, Shell SD-7438, carbofuran, and Moram.

Fall armyworms collected from the field at Tifton and in south Florida were determined resistant to *p,p'*-DDT. Moths obtained from St. Croix, V.I., and from Brownsville, Texas, remained as susceptible to *p,p'*-DDT as the Tifton laboratory strain which has been reared in the laboratory for over 100 generations. An LD₅₀ in excess of 12,050 micrograms per 30 milligrams larval weight was demonstrated for field-collected fall armyworms compared to an LD₅₀ of 10 micrograms per 30 milligrams for the susceptible strain.

7. Tomatoes

a. Greenhouse whitefly. In experiments at Beltsville, corn cobs impregnated with dichlorvos in 1962 showed insecticidal toxicity when tested 6 years later, in 1968. Freshly impregnated corn cobs were more active than commercially available resin strips or urethane foam impregnated in the laboratory.

Populations of whiteflies on greenhouse tomatoes were destroyed by continuous exposure to corn cobs impregnated with dichlorvos or to aerosol treatments containing tepp, sulfotepp, dichlorvos, or parathion applied 6 times at 4-day intervals.

Tests with corn cobs impregnated with dichlorvos and one of 3 dispersants indicated that a highly refined kerosene oil was superior to xylene or methylene chloride.

C. Biological Control (4.5 SMY)

1. Beans

a. Mexican bean beetle. In preliminary laboratory tests at Charleston, S.C., the fungus pathogen Metarrhizium anisopliae caused 100% mortality of Mexican bean beetle larvae. Beauveria bassiana, and Spacaria rileyi caused moderate mortality alone as did Beauveria combined with Bacillus thuringiensis. Limited field tests with these pathogens were unsuccessful.

2. Cabbage

a. Cabbage looper. Preliminary field cage studies at Riverside, Calif., showed that the recently discovered cytoplasmic polyhedrosis virus of the cabbage looper can infect and reduce a population under semi-natural conditions. Among several criteria measured, the first test showed an 83% reduction in total pupae, and mean pupal weights were lowered by 12 and 32 mg for males and females, respectively. Dissection of cabbage looper larvae collected from Brawley and Irvine, Calif., and reared individually at Riverside showed that Voria ruralis and Copidosoma sp. were the most abundant parasites. A high percentage of larvae infected with nuclear polyhedrosis virus were also parasitized.

Laboratory feeding experiments at Charleston, S.C., confirmed that a red strain of the bacterium Serratia marcescens, originally isolated from corn earworm eggs, was pathogenic to 2nd-instar larvae of the looper. Highest mortality, 80%, occurred when the larvae were not allowed to choose between treated and untreated meridic diets. None died when the larvae were given a choice, indicating that the bacterium is repellent to larvae. In spring and fall season tests on cabbage, Bacillus thuringiensis dusts and sprays provided plant protection equal to that provided by the most effective of currently recommended insecticides.

3. Lettuce

a. Cabbage looper. At Mesa, Ariz., collections from various cultivated hosts showed that the tachinid fly, Voria ruralis, parasitized 42% of the larvae of the cabbage looper during January-March, 30% during April-May, 5% July-September, and less than 1% from October-December. In the same collections a polyhedral virus destroyed 34% of the larvae in January-March, 22% in April-May, 46% July-September, and 84% in the period October-December, when parasitism by Voria was lowest.

4. Potatoes

a. Aphid predators. A procedure was developed at Presque Isle, Me., that proved satisfactory for applying coccinellid eggs to potato plants in the field. The eggs were applied in a coarse water spray containing 0.125 percent of agar to prevent settling in the tank during application and to enhance adhesion of the eggs to the foliage. The egg-spray mixture was applied under a constant line pressure of about 3 psi. There was little difference in percent egg hatch whether sprayed on potato foliage or on soil. The hatch of sprayed eggs was only slightly if any less than that of eggs not put through the sprayer. Based on results of earlier studies, this technique should prove suitable for field application of chrysopid eggs also.

5. Sweet Corn

a. Corn earworm. In laboratory studies at Charleston, S.C., the fungi Spicaria rileyi and Metarrhizium anisopliae caused 83 and 61% mortality, respectively, of corn earworm larvae. Beauveria bassiana was ineffective. A disease destroying corn earworm eggs of the laboratory culture was diagnosed as Serratia marcescens. In a fall season field test a Bacillus thuringiensis dust and two Heliothis polyhedrosis virus sprays were all less effective in protecting tomatoes than chemical insecticides.

b. Fall armyworm. At Lafayette, Ind., quantitative studies with fall armyworm granulosis virus indicated an LD₅₀ of 0.2 μ g of freeze-dried virus inclusion bodies for fourth-instar fall armyworms. It appears that both age and body weight of the larvae are important factors in their susceptibility to the virus. Efforts are underway to determine the effects of simultaneous infection with the fall armyworm granulosis and nuclear polyhedrosis viruses.

At Lafayette, a histopathological study of two virus diseases of the fall armyworm revealed that the granulosis virus attacks only the fat body, causes a proliferation of cells, and requires a relatively long time to produce mortality; however, the nuclear polyhedrosis virus attacks a wide variety of tissues, does not cause a proliferation of cells, and produces mortality in a relatively short period of time.

A study was conducted at Tifton, Ga., to determine the effect of age and fertility of host eggs on their suitability for parasitism by Trichogramma evanescens Westwood. The study demonstrated little or no variation in the suitability of Cadra cautella (Walker) eggs during the first 60 hours of the incubation period. All the host eggs in this age range were equally suitable for oviposition and development by the parasite. During the last 12 to 24 hours of the incubation period during which the morphological characteristics of the head of the host became evident, the eggs were progressively less acceptable for oviposition and development by the parasite.

Eggs from virgin females were often found to be suitable hosts for the parasite; however, the percentage that were suitable varied considerably. The causes for the variation were unclear.

Eggs 1-5 days old from tepe-sterilized fall armyworm moths were equally susceptible to parasitism by Trichogramma evanescens as 1- and 2-day-old control eggs. Since normal fall armyworm eggs usually hatch on the third day, chemosterilized eggs are available for parasitism at least twice as long as the normal eggs. These results indicate excellent possibilities for integration of Trichogramma with the use of chemosterilants.

6. Cross Commodities

a. Green peach aphid. A fungus epizootic that completely destroyed a greenhouse infestation of the green peach aphid in Charleston, was identified as Acrostalagmus aphidum.

b. Leaf beetles. Microscopic examination of several species of leaf beetles at Charleston disclosed protozoan infection in 60% of the banded cucumber beetles, 56% of the spotted cucumber beetles, and 54% of the bean leaf beetles sampled. No protozoa were found in striped cucumber beetles or Mexican bean beetles.

D. Insect Sterility, Attractants, and Other New Approaches to Control (5.4 SMY)

1. Cabbage

a. Cabbage looper. Studies at Riverside, Calif., showed that when sealed within 3x5-cm polyethylene bags (.05, 0.10, and 0.25 mm thickness) vapors of the synthetic sex pheromone of the cabbage looper were capable of permeating the walls of the container and attracting male moths. The thicker bag containing 100 mg of pheromone was the best of several combinations tested. Blacklight traps baited with the polyethylene bag dispensers were equally as effective as those baited with jar-sand dispensers.

In a series of experiments at Riverside, caged laboratory-reared cabbage looper males responded to synthetic sex pheromone emanating from a polyethylene dispenser up to 320 feet downwind when wind velocity was 2.5 - 5 mph and temperature was 60-63° F. When marked moths were released 350, 500, and 1000 ft downwind from the pheromone source 30, 28, and 18%, respectively, were recovered. When moths were released 160, 650, 1325, and 2020 ft from the nearest of 4 traps aligned 650 ft apart, 32, 15, 5, and 2%, respectively, of the moths were recovered. At Riverside, the efficiency of electrocutor grid traps against the cabbage looper declined during periods of high humidity in the fall. After undergoing modification of design, the grid trap baited with synthetic sex pheromone was 3.6 times more effective than a similarly baited blacklight trap during the 6-month period from December 1967 through May 1968.

A low-cost cylindrical pheromone trap constructed from hardware cloth was developed for trapping cabbage looper males at Riverside. A packet, which included sand impregnated with synthetic pheromone inside a polyethylene bag and insecticide-impregnated cheesecloth wrapped around a screen frame, was suspended from the inside top of the cage. Catches of male moths in the screen pheromone trap were comparable to those in a blacklight trap baited with pheromone.

2. Cucurbits

a. Banded cucumber beetle. At Charleston, S.C., a total of 235,245 virgin females were produced for extraction of crude sex pheromone. It was found that the yield of crude pheromone from the beetles could be increased considerably by sacrificing the females in the afternoon rather than in the morning. Extracts from 168,245 females were fractioned by chemists of the Pesticide Chemicals Research Branch. Of 61 fractions bioassayed, 13 were more attractive than the crude extract. Tests of various dispensers of the pheromone in field traps disclosed that glass jars containing paper toweling impregnated with the pheromone remained attractive for up to 68 days and were as efficient as more elaborate dispensers.

3. Lettuce

a. Cabbage looper and other caterpillars. The Mesa, Ariz., laboratory placed in operation 415 blacklight traps baited with the synthetic sex pheromone (*cis*-7-dodecen-1-ol-acetate) of the cabbage looper on March 6, 1967, on a 2240-acre ranch at Red Rock, Ariz. The traps have removed many millions of moths with the result that populations of the cabbage looper, corn earworm, beet armyworm, and salt marsh caterpillar are much lower at Red Rock than in a similar lettuce-producing ranch 12 miles away at Picacho. Dissection of trapped cabbage looper females showed a slight reduction of mating at Red Rock, and field counts on lettuce showed a reduction in the number of eggs and larvae of the cabbage looper, corn earworm, and beet armyworm.

Although trapping data and counts of eggs and larvae on lettuce indicate a reduction in moth population at Red Rock, the intensive insecticide program followed at both ranches has made it impossible to evaluate the effectiveness of light traps as a control. Arrangements are being made to maintain several untreated fields of lettuce at Red Rock for a better evaluation.

The Mesa laboratory operated from early April to early June around the perimeter of an isolated 87-acre lettuce field at Bonita, Ariz., 82 newly designed mechanical traps baited with synthetic sex lure of the cabbage looper. The traps captured approximately 25,000 cabbage looper males and reduced moth populations by about 90% below those in a ranch 12 miles away, but did not decrease the incidence of mating nor lower egg and larval infestations on lettuce.

4. Potatoes

a. Green peach aphid. At Yakima, Wash., proprietary defoliant sprays, applied to the foliage of peach trees in autumn when oviparous forms of the green peach aphid were being produced on the trees caused most of the leaves to drop prematurely before the egg-laying aphids crawled to the twigs to deposit overwintering eggs. The surviving aphids were concentrated at the rate of more than 40 per leaf on the few remaining leaves where they fell prey to syrphid fly larvae.

Studies were continued at Presque Isle, Maine, to determine the possibility of suppressing populations of the green peach aphid and spread of leaf roll virus in potatoes by eliminating Canada plum in two agricultural districts of northeastern Maine. The distribution of Canada plum in an isolated area of about 100 mi^2 in the Lee district and in a non-isolated area of 315 mi^2 in central Aroostook County was determined visually during the spring flowering period by aerial and ground survey teams. The thickets were destroyed chiefly by application of foliar or soil herbicides. In the nonisolated area about 475 thickets were found in 1967 and about 255 more in 1968. Approximately 500 of these were in rural areas. In the isolated area a total of about 100 thickets have been found, of which approximately 42 were found in 1966, 15 in 1967, and 43 in 1968. About 70 thickets were located in the buffer zone around the isolated area. The effects of Canada plum removal are being evaluated by monitoring populations of flying aphids, aphid populations on host plants, and spread of leaf roll in potatoes.

b. Wireworms. At Yakima, Wash., a sex pheromone was extracted from virgin females of the Pacific Coast wireworm and male beetles responded to crude extracts containing only a very small part of the total female equivalent.

5. Tomatoes

a. *Drosophila*. The Beltsville, Md., laboratory continued field studies for areawide suppression of *Drosophila melanogaster* in 1967 in cooperation with the Campbell Soup Co. at Rancocas, N.J. Twenty-three weekly releases, each averaging 2.5 million tepa-sterilized flies, were made between April 14 and September 13 in a 25 mi² area. The release area contained about 125 acres of commercially grown tomatoes with comparable check fields outside the area. Trapping records from the tomato fields revealed that area releases initially suppressed drosophila development in the tomato fields by 86%. In midseason more native flies were trapped from fields in the release area but following a change to direct field releases the ratio of released to native flies was reversed ranging from 0.5 to 59%. Isolated females collected from tomato fields in the release area showed an average 13% reduction in oviposition and 18% reduction in adult progeny compared to females from check areas. *Drosophila* eggs laid in slit tomatoes placed in fields in the release area indicated an average reduction of 55% for the season. Females isolated from samples taken each week from the tepa-treating cages to determine the effectiveness of the tepa treatments on flies being released showed a sterilizing efficiency of 94-99% and averaged 97% reduction in oviposition. Reduction in adult progeny varied from 94-100% and averaged 99% for the season.

In studies on the effects of marking *Drosophila melanogaster* flies for identification in a release program, tests at Beltsville indicated that dyed and undyed males were equal in mating competitiveness--6.3 vs 6.8 matings, respectively; also that longevity of dyed and undyed flies were about equal, 36 vs. 34% survival after 21 days.

6. Sweet Corn

a. Corn earworm and fall armyworm. At Tifton, Ga., research was continued on sex pheromones of the fall armyworm and corn earworm. The active principle of the female fall armyworm was isolated in pure form and identified. In an unreplicated test, the synthetic at the rate of 1 µg per ml per planchett per square yard per day for 10 days was placed in a section of the greenhouse in which a susceptible variety of corn was growing. Indications were that the pheromone had some confusing effect on the emerging insects, thereby reducing mating as well as larval damage. Further greenhouse and field studies are planned. A laboratory procedure was developed for the collection and isolation of the sex pheromone of the corn earworm. Active fractions from laboratory-reared female moths, as well as from moths caught in light traps, elicited copulatory attempts from males. The sex pheromone is located in the last abdominal segment in extremely small amounts. Work is now in progress to produce enough female moths from laboratory cultures as well as from field collections to attempt chemical characterization of the pheromone.

Irradiation of laboratory-reared corn earworm pupae, 1-2 days from eclosion, with cobalt-60 at the rate of 17.5 kr for females and 33.0 kr

for males gave almost 100% sterility. Males emerging from pupae treated with 33.0 kr were mated with nontreated females and less than 1% of the eggs oviposited hatched. Oviposition from the females emerging from pupae treated with 17.5 kr was reduced to about that of the untreated control and egg hatch was reduced to less than $2\frac{1}{2}\%$ of the eggs oviposited. Adults, less than one day old when irradiated, were sterilized with dosages of 17.5 kr for females and 33.0 kr for males. Less than 2% of the eggs laid by pairing of irradiated normal moths hatched, but these did not develop. Mating competitiveness of irradiated moths varied from slight to as much as 25% reduction during repetitive trials.

Other tests with cobalt-60 at Tifton indicated that 20 kr effectively sterilized both sexes of fall armyworms. Competitive trials showed copulation unaffected by treatment but sperm from treated males were not competitive with sperm from untreated males. Evaluation of competitiveness between tepea and cobalt-60 sterilized insects indicate no significant differences.

b. Southwestern corn borer. At State College, Miss., male southwestern corn borer pupae were subjected to gamma irradiation to determine the effect of different levels of radiation on the emergence of three pupal stages, early, mid, and late. Results to date show that the early pupal stage is much more sensitive to radiation than either the mid- or late-pupal stages. Early pupal stages one to two days old tolerated no more than 5 kr without serious emergence problems. Mid- (4 to 5 days old) and late- (7 to 8 days old) pupae withstood levels as high as 20 kr without seriously affecting normal emergence.

E. Evaluation of Equipment for Insect Detection and Control (0.5 SMY)

1. Broccoli

a. Cabbage looper. At Forest Grove, Oreg., single applications of DDT-parathion or mevinphos-parathion each followed by two applications of tepp-naled and three applications of mevinphos gave effective control of cabbage looper on broccoli. Sprays were applied at the rate of 10 or 15 gallons per acre with a Bell 47D-1 helicopter between August 9 and October 2, 1967.

2. Potatoes

a. Southern potato wireworm. A study of light trap catches at Charleston, S.C., over a period of 12 years, disclosed very little difference in the numbers of beetles taken during nights when the moon was full and nights when the moon was new.

3. Sweet Corn

a. Corn earworm and fall armyworm. A modified Steiner trap in which the

virgin females were used to attract males and prevent their escape through the use of STIKEM was used to survey natural populations of corn earworms and fall armyworms. A height of 3 feet was determined to capture significantly more numbers of males than in any other height. An increase in the number of females used as bait increased the catch but not in proportion to the increase in number of females. Females 3 days old were most attractive. Fed females caught significantly more males than non-fed females, and virgin females caught significantly more males than mated moths.

4. Cross Commodities. Studies at Forest Grove, Oregon, showed that Handy Oil RPM (supplied by the Standard Oil Company of California) has the same flow characteristics as malathion, Technical ULV at normal room temperatures, thus providing an innocuous substitute for nozzle calibration tests.

F. Varietal Evaluation for Insect Control (4.8 SMY)

1. Cucurbits

a. Cucumber beetles. Studies at Charleston, S.C., disclosed that striped and banded cucumber beetles have a similar preference for varieties of summer and winter squash. Seedlings of Zucchini and Cocoelle summer squash and Hubbard winter squash were most damaged by both species of cucumber beetles. Yellow Crookneck, Yellow Straightneck and Scallop varieties of summer squash and Table Queen variety of winter squash were least damaged. Direct comparisons of the relative damage to squash, cantaloupe, and watermelon varieties, disclosed distinct differences not only between varieties within a crop but also between crops. Taste tests of the seedlings indicated that the differences within crops were largely, if not entirely, due to the presence or absence of the bitter principle. Differences between crops, however, were not so easily explained. The relative resistance of squash probably was partly due to larger seedlings that could tolerate more feeding; however, the pronounced non-preference by the beetles for Yellow Crookneck and Table Queen squash suggests unknown chemical or physical factors that influence the beetles' choice of a host. Low levels of the bitter principle detectable by the beetles but not by taste tests may be involved in some of the varieties tested.

2. Lettuce

a. Cabbage looper. In screening tests at Riverside, Calif., involving 116 selections of Lactuca sativa and other Lactuca spp. for possible ovipositional preference by the cabbage looper, oviposition was low on 11 of the selections. One selection had 91% less eggs than the most preferred entry.

3. Strawberry

a. Spider mites. At Riverside populations were surveyed biweekly in a 68-entry strawberry plot from November 1967 through May 1968. On 8 of the entries, the mean number of mites per leaflet was less than 50% of the plot mean. On 40 of the entries, the mean per leaflet was higher than the plot mean.

4. Sweet Corn

a. Corn earworm and fall armyworm. At Tifton, Ga., the improved 81-1 and 471-U6 sweet corn inbreds that make up Walter's White were further evaluated. The improved inbreds are intended to be released to Crops Research Division, Charleston, S.C., for final testing and possible incorporation into their breeding program. A selected yellow of these inbreds is also being developed for release.

Twenty-five inbred lines of corn were evaluated at Tifton for corn earworm injury and injury was correlated with 9 characters, namely: food utilization, feeding stimulant, husk length, husk tightness, duration of fresh silk, days to mid silk, rainfall and irrigation during silking, coded husk protection, and solar radiation during fresh silk. Indications were that husk characters and laboratory feeding stimulation and food utilization were most closely and consistently related to injury. These showed the most promise for use in correlated variables in a selection program. When ears of corn were infested with corn earworm, fall armyworm, and tobacco budworm alone and in all combinations, indications were that most of the damage to the heavily injured corn was inflicted by the corn earworm. When the ears were harvested, earworm was the most prevalent.

5. Sweetpotato

a. Soil insects. At Charleston, S.C., selection from a random breeding population yielded sweetpotato clones with outstanding resistance to injury by soil insects. Several surpassed the previous standard (La 3-64) in resistance to the Diabrotica-wireworm-Systema complex and in addition possess resistance to white grubs which La 3-64 lacks. Grub resistance like sweetpotato flea beetle resistance, appears to be unconnected with resistance to the Diabrotica-wireworm-Systema complex. Four lines, however, were resistant to all three classes of insect injury.

6. Spinach

a. Green peach aphid. At the North Central Regional Plant Introduction Station, Ames, Iowa, a technique was developed for screening large numbers of spinach plants for resistance to the green peach aphid. Of a total of 2265 spinach plants (representing 73 accessions) evaluated, none were resistant to aphid attack.

7. Tomato

a. Tomato fruitworm. At Charleston, S.C., a search for fruitworm resistance in tomatoes turned up 148 promising accessions from approximately 500 screened. Real differences in fruitworm susceptibility were found among several advanced tomato breeding lines, but the level of resistance of the best was relatively low. Some evidence indicated that the resistance of these lines may not be improved by selecting within them.

8. Turnip

a. Turnip aphid. Greenhouse tests at Charleston, S.C., indicated that turnip aphid resistance in turnips may be related to light transmission through the foliage. Studies of the inheritance of turnip aphid resistance in turnips indicated an increased level of resistance in all of the crosses in which Shogoin (the resistant standard) was one of the parents. The progeny of a cross between two susceptible parents, however, were superior to Shogoin. The reason for this is not understood, but it is considered unlikely that it was due entirely to hybrid vigor.

RPA 205 - CONTROL OF DISEASES

A. Insect Vectors of Diseases (1.1 SMY)1. Potato

a. Green peach aphid. Studies in India (PL 480 project A7-ENT-33) revealed variation among clones of the green peach aphid in ability to transmit potato leaf roll and potato virus Y. However, sexual forms of the aphid have not yet been found in nature or produced in the laboratory. Until experimental colonies of the sexual forms can be established from one of these two sources, emphasis is being placed on determining optimum conditions for the aphid to acquire and transmit the two viruses.

2. Tomato

a. Tobacco whitefly. Studies were initiated in Israel (PL 480 project A10-ENT-21) to investigate the periodic acquisition related factor (PARF) of tomato yellow leaf curl virus, a semi-persistent virus, by its vector, the tobacco whitefly. Although viruliferous insects became progressively less efficient in transmitting the virus after initial acquisition, they were unable to reacquire the virus until transmission from the initial acquisition had completely ceased. Inability to reacquire the virus during the persistence period appeared connected with some active process in the insect's body. Homogenates prepared from crushed viruliferous whiteflies and fed to virus free whiteflies before they were given an acquisition feeding reduced their ability to transmit the virus. The PARF factor was found in bodies of whiteflies 24 hours after they had completed a 24-hr acquisition feeding but not in those at the close of

the feeding period nor in those examined 7 days after acquisition feeding which was near the end of the cycle of inoculative loss in the insect. Transmission efficiency of non-viruliferous insects was reduced when they acquired the factor before acquisition feeding. Application of the factor to viruliferous insects after acquisition feeding did not reduce the mean number of transmissions per insect.

3. Cross Commodities

a. Leafhoppers. In studies on Indian Jassidae with particular reference to Circulifer and related genera and their importance as vectors of plant virus diseases (PL 480 A7-ENT-22), 24 genera of Cicadillidae were collected from agricultural crops, fruits, ornamentals, and weeds in the area near Ludhiava, India. Included were at least 3 species of Circulifer, one of which was tentatively identified as C. tenellus. Although symptoms resembling curly top virus have been observed in India, transmission by leafhoppers to indicator hosts for positive identification has not been made.

RPA 701 - INSURE FOOD PRODUCTS FREE OF TOXIC RESIDUES

A. Insecticide Residue Determinations (0.2 SMY)

1. Cabbage. At Charleston, S.C., spray applications of Azodrin at 0.5 lb active ingredient/acre resulted in residues of 0.69, 0.57, 0.38, 0.23, and 0.07 ppm 1, 5, 8, 15, and 22 days after treatment. At 1 lb/acre residues ranged from 1.1 ppm after 1 day down to 0.17 ppm after 22 days.

2. Cucumber. A 10% granular formulation of Union Carbide UC-21149 was put into the soil of greenhouse-grown cucumbers at rates of 22.4, 44.8, and 89.6 kg of active ingredient/hectare. Cucumbers, cucumber foliage, and greenhouse soil were sampled 11 and 26 days after treatment. Combined residues of UC-21149, its sulfoxide and sulfone in ppm in cucumbers at the successive sampling periods were 7.8 and 4.6 for 22.4 kg/hectare; 12.6 and 6.2 for 44.8 kg/hectare; 12.5 and 13.6 for 89.6 kg/hectare. The combined residues in ppm in cucumber foliage for the same periods were 131 and 149 for 22.4 kg/hectare; 399 and 268 for 44.8 kg/hectare; 467 and 400 for 89.6 kg/hectare. Soil residues for the same periods were 20.2 and 20.7 ppm for 22.4 kg/hectare; 70.1 and 9.0 ppm for 44.8 kg/hectare; 71.0 and 32.1 ppm for 89.6 kg/hectare.

3. Potatoes. At Yakima, Wash., foliage sprays of carbofuran were applied to potato plots at the rate of 1.12 kg of active ingredient/hectare 54 and 89 days after planting. Potato samples taken 45 days after treatment showed no detectable residues of carbofuran.

In tests with ultra-low volume spray applications at Yakima, oxydemeton-methyl plus a red dye was applied at 0.75 lb/acre to a potato field. Residues collected on filter papers placed horizontally in the plants

6 inches above ground level indicated deposits of 0.44 lb/acre with a roller-pump applicator with spinning discs, 0.08 with a spray applicator with hoods, and 0.05 with conventional equipment.

At Yakima, carbofuran was applied to the soil at planting time at 2.5 lb/acre. Tubers taken after 69 days and at harvesttime (83 days after treatment) contained no detectable residues (less than 0.01 ppm).

4. Cross Commodities. Greenhouse grown tomatoes, lettuce, and cucumbers at Beltsville, Md., were analyzed for dichlorvos, which had been applied as a 10% aerosol at the rate of 1 gram active insecticide per 1,000 cubic feet or as 5% dichlorvos impregnated on corn cobs for periods of 16 days. The concentration of dichlorvos in the air 2 hours after release of 10% aerosol was about 0.12 μ g/liter. Air samples from the impregnated corn cob treatment contained about 0.3 μ g/liter after 16 hours of continuous exposure; concentrations in the air when 16-hour nightly exposures were made over the testing period varied from about 0.05 to about 0.02 μ g/liter. Tomato and cucumber fruits retained less dichlorvos than their foliage (<0.02 ppm in fruit). Less than 0.013 ppm was found in lettuce under all test conditions.

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DECIDUOUS FRUIT, TREE NUT, GRAPE AND BERRY INSECTS

Entomology Research Division, ARS

USDA and Cooperative Programs

Location of Intramural Work	Scientist Man-Years FY 1968		
	Research Problem Area		
	204	205	Total
Deciduous Fruit			
California	: 0.9	: 2.2	: 3.1
Georgia	: 1.1		: 1.1
Indiana	: 2.9		: 2.9
Ohio	: 0.7		: 0.7
Washington	: 6.0		: 6.0
West Virginia	: 1.0		: 1.0
Total	: 12.6	: 2.2	: 14.8
Tree Nuts			
Georgia	: 3.0		: 3.0
Louisiana	: 1.0		: 1.0
Ohio	: 0.1		: 0.1
Total	: 4.1	: 0.0	: 4.1
Small Fruits			
Ohio	: 0.2		: 0.2
Total	: 0.2		: 0.2
Total	: 16.9	: 2.2	: 19.1

Intramural program is supplemented by extramural support representing
 (a) 0.5 SMY at State Agricultural Experiment Stations. 1/

1/ RPA 204 - 0.5 SMY

Problems and Objectives

Insects and mites attacking deciduous fruits, tree nuts, grapes, and berries reduce yield, lower quality, and contaminate the crop with insect parts. Some spread plant diseases that reduce the productivity of the host plant. Losses to these crops exceed \$238.5 million annually. Present control methods rely principally on control with insecticides which increase production costs and may leave objectional residues. Development of resistance to certain insecticides by insects and mites is also a serious problem.

Major objectives of the research are to develop and evaluate alternative ways to control insect and mite pests by use of:

1. Insecticides that will minimize or avoid objectionable chemical residues.
2. Insect sterilization techniques.
3. Parasites, predators, pathogens, or other biological agents.
4. Attractants, repellents, and other response stimuli.
5. Ecological and cultural management practices.

Progress - USDA and Cooperative Program

RPA 204 - CONTROL OF INSECT PESTS

A. Basic Biology, Physiology, and Nutrition (5.2 SMY)1. Deciduous Fruits

a. Codling Moth. Facilities at Yakima, Wash. permit preparation and handling of 32 trays of artificial medium per day for rearing codling moth. The median yield over a 3 month period was about 125 moths/tray.

Basic studies on the influence and significance of photoperiod and light on diapause and development of the codling moth are being conducted under a grant to Washington State University. Larvae exposed in a field chamber for 10 days, starting on November 20, were placed in constant dark to complete development. The last light experience during field exposure was at hour 18 after dawn. The controls (no light supplementation) yielded 40% pupation, continuous incandescent yielded 31% pupation, 1 hour of incandescent yielded 79%, 6 spaced flashes of light yielded 66%, and a single flash yielded 63% pupation.

b. Peach Tree Borer. At Fort Valley, Ga., cast skins of emerged peach tree borers and lesser peach tree borers were collected from 34 sample trees between April 30 and November 18. More (826) lesser peach tree borers emerged during the season than did peach tree borers (92). Lesser peach tree borer emergence began in early May and continued at a high level until October. Emergence of peach tree borers began about July 1

and continued at a low level until early September when it peaked sharply then declined to the end of that month. Cocoons of the peach tree borer were collected from the orchard and subjected to altered light cycles in environmental chambers. Two days was sufficient to entrain emergence from the orchard's solar day to the altered light cycles. Adult emergences occurred in synchrony with the altered light cycles (3:00 a.m. to 4:00 p.m. and 9:00 a.m. to 10:00 p.m.), about an hour after "sunrise." Females emerging and calling males first in one light cycle retrained their time of calling within 2 days to synchronize with the opposite light cycle when placed in that opposite cycle after their first call.

In a research grant to North Carolina State University an array of synthetic diets were evaluated for rearing the peach tree borer throughout the larval stage. None of the diets allowed growth beyond the third instar.

c. Plum Curculio. At Fort Valley, Ga., the preoviposition period of the female plum curculio was determined for laboratory conditions of 80° F, 60% relative humidity and constant light. Oviposition began on the fifth day. The model preoviposition period was 11 days; 54.7% of the females had oviposited by the thirteenth day. One percent failed to oviposit and 15% had died at the end of 25 days of adult life. A time lag exists between mating and oviposition by plum curculios and decreases as the females age. For those few females that made fertile matings at six days of age, two days elapsed before oviposition began. One day elapsed between mating and oviposition by those females mating between seven and ten days of age. From eleven days of age onward, mating occurred and oviposition began within 24 hours of the time the females were placed with males.

d. Pear Psylla. Studies at Riverside, Calif., have shown that entrance of pear psylla (Psylla pyricola) adults into diapause depends upon reduction in day length during nymphal stages prior to the last instar. Adults in southern California assumed this resting form in late summer rather than autumn, thus restricting population increases. In northern California, longer periods of reproduction and denser populations have been noted.

Under a grant to Washington State Agricultural Experiment Station basic studies on the behavior of the pear psylla (Psylla pyricola Foerster) are being conducted. Females laid an average of 207 fertile eggs each when mating was delayed for 14 days after their emergence and 231 each when delayed 28 days. An average of 501 eggs were produced by females mated every 7 days. Females kept from mating until 14 or 28 days after their final molt did not live as long as those allowed free mating.

e. Scales and Mites. At Fort Valley, Ga., two seasons of life history study of the white peach scale indicated that 4 generations and a possible partial fifth generation occur each year. Peaks of crawler activity occurred in late April, the end of June, mid August, and early October.

A partial fifth generation occurred in late November in 1967.

At Athens, Ga., greenhouse plantings of apples, peaches, and pecans were established by the Georgia Agricultural Experiment Station for the rearing of field-collected eriophyid mites for study under a cooperative agreement. A detached leaf method is being employed for biological studies and studies of host plant resistance.

2. Tree Nuts

a. Shuckworms. At Albany, Ga., the hickory shuckworm has been reared through 7 continuous generations on a diet of soaked pinto beans, wheat germ, tortula yeast, ascorbic acid, mold inhibitors, agar and water. Pecan foliage and pecan nuts have been used to stimulate moths to mate. Eggs were obtained on a year-round basis by the use of foliage during the winter months and by the use of pecans when available. Moths reared on an artificial diet will oviposit from 2 to 452 eggs, mate from 1 to 5 times, and live 20 to 30 days when held in a glass house. Eighty-five to 92 percent of the eggs hatch. Shuckworm moths began emerging from naturally infested pecan shucks March 21. Peak emergence was from April 10-13 and ended May 6. A total of 5,545 moths emerged, of which 47.7% were males and 52.3% were females.

Data taken from a blacklight trap which automatically changes the killing-collecting containers at hourly intervals revealed that maximum hickory shuckworm moth activity was during the first three hours after sunset. More males were caught during the 1st hour after sunset and females during the 3rd. Moth catch progressively declined for 5 hours, then both sexes showed increased activity during the 9th hour after sunset after which activity again declined.

3. Small Fruits

a. Grape Berry Moths. Segregation of 32 non-diapausing grape berry moths at Wooster, Ohio, from an original field culture produced 48 first-generation nondiapausing and 136 second-generation nondiapausing moths. Female moths laid eggs on grape berries in the laboratory, and first-instar larvae that hatched from these eggs were transferred to a modified alfalfa diet media.

B. Insecticidal and Cultural Control (3.6 SMY)

1. Deciduous Fruits

a. Codling Moth. During the 1967 growing season experiments conducted at Vincennes, Ind., for control of codling moth showed the following percent efficiency at harvest: Azinphosmethyl 95.7, carbaryl 88.1, ryania 55.0, granulosis virus 45.3, Thuricide (semi-weekly applications) 34.9 and (weekly) 0.0, and released Trichogramma 24.1.

b. Peach Tree Borers. At Vincennes, Ind., superior oil, parathion, and endosulfan exhibited a high degree of toxicity to eggs of lesser peach tree borers. Dimethoate, demeton, and azinphosmethyl were of moderate toxicity, and binapacryl, dicofol, and tetradifon were low in toxic effect.

c. Pear Psylla. At Yakima, Washington, applications of three spray oils, PGSO-1, PGSO-2, and Volck Supreme, and two experimental compounds, were very effective against the pear psylla.

d. Spider Mites. Three applications of Sea-Born, a seaweed extract, reduced two-spotted spider mites on lima bean test plants at Kearneysville, W. Va. The seaweed extract did not appear to be directly toxic to Tetranychus urticae. The population reduction may have been the result of some adverse nutritional effect.

2. Tree Nuts

a. Miscellaneous Insects and Mites. At Shreveport, La., a single application of Geigy GS-13005 (.44 lb/100 gal) and demeton (.25 lb/100 gal) gave excellent control of the mite, Eotetranychus hicoriae and a yellow aphid on pecan. Dicofol (.37 lb/100 gal) gave excellent mite control but was ineffective against yellow aphids. Parathion (.30 lb/100 gal) gave fair control of both insects one day after treatment but mites were numerous thirteen days after treatment. Sulfur (4.0 lb/100 gal) gave only limited mite and aphid control.

At Albany, Ga., 5 conventional ground sprayer applications of azinphosmethyl at the rate of 1/2-lb actual/100 gal were compared with 5 ULV aerial applications at the rate of 1 lb actual/acre for control of the black pecan aphid and the hickory shuckworm on pecan. Both treatments provided excellent control of aphids and shuckworm when compared to untreated checks.

At Shreveport, La., Bidrin was poured into holes in the trunks of pecan trees at the rate of 2 ml per inch of trunk diameter. The material was translocated to leaves in a quantity sufficient to kill spittlebug but not phylloxera.

At Wooster, Ohio, two spray applications of a combination of carbaryl and malathion gave satisfactory control of walnut curculio and butternut curculio on butternut trees.

Soil applications of either dieldrin or heptachlor, at 10 pounds actual per acre, applied in late summer, gave significantly better control of emerging walnut husk maggot adults than the untreated check. There was no significant difference between the two insecticides.

3. Small Fruits

a. Mites. At Wooster, Ohio, European red mites were controlled on Concord grapes by the addition of dicofol to either the regular prebloom and petal-fall sprays or to the petal-fall and first-cover sprays.

C. Biological Control (3.4 SMY)

1. Deciduous Fruits

a. Codling Moth. At Vincennes, Ind., codling moth eggs from 0- to 2-day old were readily parasitized by Trichogramma minutum. Two to 3-day old eggs were parasitized in low numbers, while eggs over 3 days old did not support development of Trichogramma. In laboratory and field tests both Trichogramma minutum and T. cacoeciae, emerging from Angoumois grain moth eggs, readily parasitized codling moth and red-banded leaf roller eggs. Both parasite species are capable of development to functional adults in eggs of each of these two hosts. Codling moth eggs from a laboratory colony were affixed to apple trees in which T. minutum and T. cacoeciae were released, to adjacent trees, and to 1-foot stakes in the ground cover. The two species parasitized 53 and 80 percent, respectively, in the release tree but only 3 and 17 percent in trees 20 feet away. Eggs placed on stakes at 5-, 25-, and 50-foot distances from the release trees had 80, 51, and 67 percent parasitization by T. minutum and 59, 59, and 40 percent by T. cacoeciae. Natural parasitization in a non-release orchard was 5 percent.

b. Spider Mites. Cages covered with muslin cloth were used at Kearneysville, W. Va., to study the activity and population differences in pure cultures of Trichogramma urticae and mixed cultures of T. urticae and Amblyseius fallacis mites on bean plants. It was found that the cages provided isolation from invasion of A. fallacis up to 6 weeks. Mixed populations of T. urticae and A. fallacis, starting with 5 A. fallacis/cage, added to a T. urticae population of 300 motile forms/leaf, averaged less than one T. urticae motile form/leaf 30-35 days after addition of A. fallacis. Data indicated that one A. fallacis could eliminate up to 13 T. urticae.

c. Lady Beetles. Studies at Wenatchee, Washington, have shown that the adults of the convergent lady beetle, Hippodamia convergens, were very susceptible to residues of azinphosmethyl, binapacryl, carbaryl, DDT, diazinon, endosulfan, Morestan and parathion. Mortality was essentially total at 24 hours at both normal field rates and one-half field rates. The contact toxicity at both levels of binapacryl, endosulfan and Morestan at 24 hours was 50% or less while DDT resulted in 75-80% mortality. The contact toxicity of azinphosmethyl, carbaryl, diazinon and parathion was 100% at 6 hours. Dosage-mortality curves, established through topical application, indicated toxicities in the order azinphosmethyl>parathion>carbaryl>diazinon>DDT>endosulfan>binapacryl. Morestan was not evaluated topically due to solubility problems.

D. Insect Sterility, Attractants, and Other New Approaches to Control
(5.4 SMY)

1. Deciduous Fruit

a. Codling Moth. At Yakima, Wash., in 1966, traps baited each week with 10 female codling moths were placed every 200 feet for 1,000 feet in each cardinal direction from a 15-acre apple orchard in which 580,334 sterile male moths were released. With the exception of the trap line east of the orchard, there was a steady decrease in catch as the distance from the orchard increased. There was an increased catch in the trap 1,000 feet east of the orchard over the one 800 feet east of the orchard.

In 1967, 8288 irradiated sterile codling moths of each sex per acre were released from a helicopter into a 93-acre apple orchard near Yakima. No insecticide sprays for codling moth were used in this block, but ethion, oil, and tepp were applied to 83 of the 93 acres to control spider mites. At harvest, 0.26% of the apples in the release orchard and 0.24% of the apples in a similar orchard treated with insecticide were damaged by the codling moth; however, most of the damage in the release orchard occurred near stacks of propiles or piles of cut applewood.

The effects of different doses of gamma radiation on codling moth longevity and oviposition have been tested at Yakima. Longevity of adults irradiated at 30-35 krads as pupae or adults is greater than that of untreated adults or those treated with 25 or 45 krads. Irradiated females mated to untreated males produced fewer eggs than untreated checks or untreated females mated to irradiated males.

At Yakima, blacklight and sex pheromone traps compete with one another when the two are in close proximity. Blacklight trap catches reflect this competition in reduced catches of male codling moths. The female moth catch is unchanged. Blacklight traps, in the absence of competitive pheromone traps, catch 5 to 10% more males than females. However, when a competition exists, the ratio of males to females is reversed (5 to 10% more females than males).

No codling moth or red-banded leaf roller toxicants were applied to a 20-acre block of apples located within a 200-acre commercially productive orchard at Vincennes, Ind. Twenty traps, containing 5 virgin females of each of these 2 species, were maintained in the block throughout the season. A total of 209 male codling moth and 16,777 male red-banded leaf rollers was recovered from the traps. Harvest counts showed that 4.4% of the fruit in the experimental block was injured by codling moth and 6.9% by red-banded leaf roller; damage to the grower's block was 0.2% and 0.3%, respectively. The value of sex traps as a survey tool was demonstrated and will be used as an aid to properly timing insecticide sprays next season.

b. Peach Tree Borers. A total of 5,600 female equivalents of lesser peach tree borer extracts was fractionated by the Pesticide Chemicals Research Branch at Beltsville. Sixty-seven fractions were bioassayed by the Vincennes, Ind., laboratory. In field tests, 11 fractions caught males. These are the first fractions of the pheromone of the lesser peach tree borer demonstrating activity.

Marked laboratory-reared males were released in the center of the 45-acre orchard at Patoka (Vincennes) Ind., to determine the efficiency of 60 traps, each containing 6 virgin females. Seven releases (a total of 3,206 marked males) were made. The average recapture percentage was 81.62%, with a range of 69.44 to 91.71%. Eight releases, consisting of a total of 4,987 marked males, were made at different distances from the Patoka peach orchard. The following percentages of released males were recovered: 1/4 mi-47.10%, 1/2 mi-43.12%, 3/4 mi-22.55%, 1 mi-21.87%, 1-1/2 mi-17.01%, 2 mi-14.74%, 3 mi-4.37%, and 4 mi-6.07%. Seven additional marked males were recovered in traps outside the designated trap area at the Schultz peach orchard, about 7 mi northeast of the Patoka orchard. Of the 7 moths, 3 were caught at 3 miles from the release point, 2 at 4 miles, 1 at 9 miles, and 1 at 10 miles.

At Vincennes, Ind., glass beads, filter paper, sea sand and Myverol (distilled monoglycerides of lard) were used as carriers for crude extracts of lesser peach tree borer females. Each of the carriers were placed in separate gallon-size sticky traps and charged with 100 female equivalents of borer extract. The filter-paper traps caught more males than the combined total of the carrier traps (1,192 to 663). The Myverol traps were the least effective, not only in the number of males caught but also in the duration of effectiveness. Although the traps with glass beads and sand did not catch as many borers as the filter paper traps, they caught moths for 16 to 18 days, compared with 4 days for the filter-paper traps. Glass beads and sea sand show promise as carriers for the sex pheromone of lesser peach tree borers.

c. Plum Curculio. At Fort Valley, Ga., continued study of the effect of gamma radiation on the plum curculio revealed that males were not sterilized below 8 kr, but at that dosage longevity was greatly decreased. Eggs from normal females mated to irradiated males were just as infertile 10 days after the mating as immediately after the mating. Females treated with 8 kr were completely sterile and their production of eggs was greatly reduced. The number of larvae emerging was reduced by 90% when treated males (6 kr) were placed in competition with normal males for normal females at the ratio of 40:1:1, respectively.

d. Red-banded Leaf Roller. A synthetic red-banded leaf roller sex attractant (ENT 28959), in amounts of 10, 100, 1,000, and 10,000 female equivalents was placed on filter-paper tubes in field traps at Vincennes, Ind. The tubes were placed in gallon-size cardboard traps, coated with Stikem, and hung on apple and peach trees inside a 1/2-acre cage. Two

checks, one containing 5 and the other 10 virgin females per trap, were used. On alternate days, red-banded leaf roller males were released into the cage. Although the virgin-female traps were removed after 2 weeks, 90% of the total catch was caught by the 2 checks. Although the synthetic sex lure trap catches were low, the lures were still effective in catching males up to 21 to 25 days. As the strength of the synthetic lure was increased tenfold, there was about a twofold increase in male recoveries over the next lower test dosage.

Female red-banded leaf roller moths were used as lures in 43 traps located in 2 apple orchards at Kearneysville, W. Va. An average of 8.5 males per trap were captured in a two-week period. A synthetic pheromone (ENT 28959), used at 50 female equivalents per trap, retained slight moth attractivity through a period of 6 days in field traps. One-gallon-size cartons were found to be more efficient as traps than one-quart or one-pint cartons.

On the day of their emergence, virgin female red-banded leaf rollers were each individually caged and placed in gallon-size sticky traps, which were placed in apple trees at Vincennes, Ind. Younger females were more attractive than older ones and were most attractive during the first 2 days of adult life. As the moths aged, there was a gradual decrease in attractiveness. On the 9th and 10th days, females were about half as attractive as the newly-emerged adults.

e. Other Fruit Insects. Studies of trap recovery of the oriental fruit moth during the 1967 growing season under a grant to Colorado State University have shown the sex attractant trap to be superior to the standard liquid bait trap. It was found that the moths will disperse more than 300 feet from a release point in a 24-hour period.

Standard bait sprays of corn hydrolysate and malathion (WP), were applied to 16 apple trees at Wooster, Ohio, at weekly intervals in 1967. Apple maggot infestation was only 19% as compared to 100% the previous year when unsprayed.

Sticky board traps baited with a corn protein hydrolysate-dibasic ammonium phosphate bait mixture were effective in determining the peak abundance dates of the cherry fruit fly and the black cherry fruit fly in cherry orchards near Wooster, Ohio.

2. Tree Nuts

a. Shuckworms. At Albany, Ga., tests were conducted to determine the merits of various blacklight trap designs for catching hickory shuckworm moths. A standard 15-watt blacklight trap operating on alternating current caught slightly more total insects by weight and slightly more shuckworms than a similar trap operating on direct current. A trap with 5 15-watt bulbs and a 20" diameter funnel equipped with a fan caught 40% more insects by weight and 8% more shuckworm moths than a similar trap without a fan.

A trap with 5 15-watt bulbs caught 61% more insects by weight and 179% more shuckworm moths than a trap with a single 15-watt bulb.

During 1967 a relatively isolated 8-acre pecan orchard of 94 trees near Albany, Ga., was equipped with 33 evenly distributed standard 15-watt blacklight traps. The total calculated number of moths removed from the orchard by the traps was 4,834. Shuck infestation at harvesttime was 14.6%. The nut crop harvested from trees about .3 mi from the test orchard was about 80% infested.

b. Pecan Weevil. Under a grant to Texas A&M University, a study on the use of ionizing radiation and chemosterilants is being made for pecan weevil control. The study is being hindered by the occurrence of high mortality within the control population.

c. Walnut Insects. Under a grant to the California Agricultural Experiment Station at Berkeley, studies on the navel orangeworm, Paramyelois transitella (Walker), on walnuts, indicate that pheromone traps are a useful tool for evaluating field populations when only irradiated males are released. There is evidence that the pheromone traps lose their effectiveness when both males and females are released. Releases of up to 20,000 sterilized individuals per acre have not resulted in adequate overflooding, apparently because the laboratory strain is not adequately competitive with wild moths.

At Wooster, Ohio, standard bait sprays of corn protein hydrolysate and malathion (WP), were applied at weekly intervals. Walnut husk maggot infestation in English walnuts was only 5% compared to 50% the previous year when unsprayed.

3. Small Fruits

a. Blueberry Maggot. At Wooster, Ohio, blueberry maggot appeared to be completely controlled by weekly spray applications of a standard bait spray of corn hydrolysate and malathion (WP). The original infestation had been reduced with bait sprays for the past 4 years.

b. The grass spittle bug Philaneus spumarius Linnaeus as nearly grown nymphs on strawberries near harvesttime were effectively controlled by endosulfan sprays (1.0 lb/100 gal) in tests at Beltsville, Md.

E. Evaluation of Equipment for Insect Detection and Control (0.3 SMY)

1. Deciduous Fruits

a. Codling Moth. A blacklight trap, mounted on the roof of a 7x7x7-ft wood and screen walk-in cage, has proved to have value as a monitoring instrument for measuring codling moth and other insect activity in orchards at Vincennes, Ind. This trap, set in an unsprayed

apple orchard, provided capture records that were more reliable than 20 bait jars at 10 stations for demonstrating emergence peaks and being an index to the numbers and activity of codling moth in the orchard. The cage trap also enabled us to collect insects alive for our research use.

At Albany, Ga., equipment has been developed for collecting and separating pecan shucks from leaves and trash in the field. About 2,050 pounds of shucks infested with hickory shuckworm larvae were returned to the laboratory in plastic lined paper bags sealed and refrigerated at about 40° F. The shucks are being removed from refrigeration periodically to provide moths for the laboratory. Moths were available from April 21 through June 20 at a rate of 114.7 per day. Mortality from storage did not appear excessive. Equipment has also been developed for collecting moths emerging from pecan shucks, immobilizing and sexing them.

F. Varietal Evaluation for Insect Control

Under a grant to the Kentucky Agricultural Experiment Station some of the essential oils extracted from leaves of strawberry clons that were classed as mite resistant exhibited about 100 times the repellency to feeding mites as extracts from susceptible clons. Some of the amino acids that have been extracted from strawberries have been identified and found to differ in their concentration in mite susceptible and mite resistant clons. The strawberry variety Citation is the standard for susceptibility and Surecrop for resistance. The unnamed variety #21169 is more resistant than Surecrop.

RPA 205 - CONTROL OF DISEASES

A. Insect Vectors of Diseases (1.1 SMY)

1. Deciduous Fruits

a. Pear Psylla. An experiment initiated 5 years ago in evaluating the actions and effects of pear psylla, *Psylla pyricola*, as a vector of pear decline virus was completed at Riverside, Calif. Field cages, screen covered, 9 feet high, initially enclosing 20 pear trees each, were employed. The trees were of a pear decline susceptible type, Bartlett variety on oriental pear rootstocks. Of 40 trees exposed to pear psylla transferred from pear decline infected sites, 13 became infected with pear decline.

Insect transmission work with pear psylla, *Psylla pyricola*, and pear decline virus revealed an uniquely useful indicator tree for pear decline disease in the Magness pear variety. Three and four-year-old field trees, grown on own-roots, were inoculated by caged viruliferous psylla. The symptoms of disease appeared during the following year and consisted of a pre-mature leaf drop beginning in mid-August, which left the trees bare before the time of normal autumn leaf fall. In subsequent years, the

affected trees showed little new terminal growth and appeared to be in a slow-decline condition. Check trees fed upon by non-viruliferous psylla remained healthy.

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CITRUS AND SUBTROPICAL FRUIT INSECTS

Entomology Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years FY 1968			
	Research Problem Area			
	204	205	701	Total
<u>Citrus</u>	:	:	:	:
California	:	2.3	0.7	0.0
Florida	:	2.0	0.6	0.0
Texas	:	1.9	0.0	0.1
<u>Total Citrus</u>	:	6.2	1.3	0.1
<u>Subtropical Fruit</u>	:	:	:	:
Florida	:	0.4	0.0	0.0
Hawaii	:	9.6	0.0	0.4
Mexico	:	4.0	0.0	0.0
<u>Total Subtropical fruit</u>	:	14.0	0.0	0.4
<u>Total</u>	:	20.2	1.3	0.5
				22.0

Intramural program is supplemented by extramural support representing PL 480 funds in 4 countries representing 311,982 U.S. dollars equivalent.^{1/}

1/ RPA 204

Problems and Objectives

Insects and mites attacking citrus and subtropical fruits reduce yield, lower quality, spread plant diseases, and contaminate fruit with insect parts. Insecticides required for their control leave undesirable residues and increase the cost of production. Losses to citrus alone exceed \$217 million annually. Reduction of these losses could result in net benefits of \$184 million annually by 1980. Three species of subtropical fruit flies that occur in Hawaii but not in the continental United States pose a serious threat to agriculture of the southern States. Another species is now established in Florida. Methods to avoid their introduction and to eradicate if introduced are necessary to avoid an estimated potential loss of \$42 million and the additional control costs.

Major objectives of the research are to develop and evaluate methods of control to utilize:

1. Chemicals that will minimize or avoid objectionable residues.
2. Nonchemical approaches to control including biological agents, attractants, and sterilization techniques.
3. Treatments to eliminate infestations in quarantined fresh fruits.
4. Chemical, biological, or ecological practices to avoid plant disease transmission by insect vectors.

Progress - USDA and Cooperative Program

RPA 204 - CONTROL OF INSECT PESTS OF FRUIT AND VEGETABLE CROPS

A. Basic Biology, Physiology, and Nutrition (5.1 SMY)

1. Citrus

a. Brown Soft Scale. High winds and heavy rainfall associated with Hurricane Beulah caused significant drop of citrus leaves infested with brown soft scale at Weslaco, Texas. This was followed by sharp increases in scale infestation and late seasonal population peaks.

Observations on sites of scale attachment revealed that in the early season they are much more abundant on the stems of citrus trees. In January, February, and March, 52%, 44%, and 69% more scale, respectively, were found on the stems than on the leaves. In May, a complete reversal occurred and the scale became more abundant on the leaves, and by June, 84% of the scale collected were found on the leaves.

In citrus groves at Weslaco, Texas, the 7 rows of citrus trees immediately downwind of salt cedar and sour orange windbreaks showed significantly lower scale populations than rows farther out. Observations on glass

"sticky plates" coated with petroleum jelly showed higher entrapment of brown soft scale crawlers and Texas citrus mites 180' from the windbreak than 30' away.

b. Thrips. A method of rearing citrus thrips on detached leaves was developed at Riverside, Calif. The life cycle at 86° F requires 13 to 14 days. This technique has made possible laboratory studies of this insect for the first time.

c. Gall Midges. At Allahabad, India, fall larval populations of gall midge, Dasineura citri Glover, affecting citrus varied from 10 to 12 each in citrus buds. Spring populations were similar. The incubation period of the egg in the autumn was 34 to 40 hours, the larval period extended 10 to 12 days, and the pupation period 4 to 6 days. Cocoons were found as deep as 4 inches in the soil at Allahabad. In dry periods droplets of water were highly attractive to the adults.

2. Subtropical Fruit

a. Caribbean Fruit Fly. At Orlando, Fla., 5 complete generations of Anastrepha suspensa have been reared under laboratory conditions with satisfactory increases in returns from numbers of eggs set on each succeeding generation.

b. Gall Midges. At Allahabad, India, under a PL 480 project, it was observed that mango buds infected by gall midge, Procystiphora mangiferae, never open naturally. Heavy infestations caused up to 100% loss of buds. P. mangiferae and Erosomyia indica populations were very low in the off-season of October and November. The latter is the most serious of the 3 species studied in India. It attacks the mango in 4 stages of development from preflowering shoot buds to small fruits. A DDVP aerosol spray was only partially effective in knocking down adult midges in population counts.

Research in Allahabad, India, under PL 480 showed that larvae of gall midges, Udumbaria nainiensia, attacking figs were able to survive long exposures (up to 25 days) in water. During heavy rains mature larvae leave figs very rapidly.

c. Subtropical Fruit Flies. At Hilo, Hawaii, Jerusalem cherry, wild momordica, and loquat were the most heavily infested hosts of 23 plant species collected during the period of June 1967 to May 1968. Cherries were infested by the Mediterranean fruit fly, momordica by melon fruit flies, and loquat by oriental and Mediterranean fruit flies. Mixed infestations of oriental and Mediterranean fruit flies were recovered from methley plum, mountain apple, litche, coffee, loquat, and guava. Soursop, ceylon gooseberry, acerola and tree tomato, which are known fruit fly hosts, failed to yield any infestations from small, limited samplings.

Mating behavior of fruit flies was observed at temperatures ranging from 58 to 68° F at elevations of 3,000 to 4,000 ft. Temperatures of 59 to 61° F inhibited oriental fruit fly mating and reduced mating of the melon and Mediterranean fruit flies. At 66 to 68° F the mating behavior of the oriental fruit fly continued to be inhibited but not so with the other two species.

At Honolulu, Hawaii, studies have shown that adult fruit flies must have sugar soon after emergence to survive, but may live several days without water. With 2-day old adult oriental fruit flies, mortalities were 9 to 10% for sugar only as compared with 98 to 99% for water only. Melon flies were able to survive 5 days with sugar but only 1 to 2 days with water but without sugar. In a normal Hawaiian environment (48 to 76% R.H.) Mediterranean fruit fly adults can do without water for 3 days; in an artificially-induced drier environment, only 1-1/2 to 2 days. The percent emergence from normal and irradiated medfly pupae placed in natural and dry environments 2 days before emergence was found to be almost identical.

Fruit flies also were fed Jello as a substitute for sugar and water in the adult diet. Oriental fruit fly egg deposition and hatch were the same on a Jello-hydrolyzed protein as in the sugar-water-HP diet. Melon fly females lived longer on Jello than on sugar and water. Male longevities were identical.

At Honolulu, Hawaii, preliminary isozyme surveys of oriental fruit flies were made. Electrophoretic analysis of acid phosphotases, amylases, leucine-amino-peptidases, and esterases in newly-emerged 2-week-old and 3-week-old white and yellow marked oriental fruit fly males and females indicated clear-cut differences only in the esterase system. Among 15 ester isozymes separated, there were 2 which were present in white and yellow strain females and in yellow strain males but not in white strain males.

At Honolulu, Hawaii, the dispersal and survival of a white-marked lab strain of the oriental fruit fly in the F₁₀₀ generation and a wild yellow-marked strain lab-reared for 10 generations were compared by means of 4 sterile releases. Recoveries from 32 to 36 methyl eugenol baited traps at selected sites on concentric circles 1/8, 1/4, 1/2, 3/4, and 1 mile out from the release sites showed that males of the white-marked strain were recovered in significantly greater numbers than those of the yellow strain in time and space.

B. Insecticidal and Cultural Control (2.7 SMY)

1. Citrus

a. Screening New Insecticides. Twenty-seven out of 44 experimental materials screened for effectiveness against citrus rust mite at Orlando, Fla., gave high mortality at 20 ppm. Ten were effective at 1 ppm or less.

b. Insecticide Sprays. Brown soft scale populations on potted citrus trees increased 7-1/2 fold between 7 and 8 weeks after treatment with methyl parathion, while the check showed a mean increase of 11.4% during the same period in tests at Weslaco, Tex. Trees treated with azinphos-methyl remained free of scale from the 4th through the 8th week before being reinfested.

Despite average reductions in the number of cotton sprays applied to cotton, only 1/3 the usual number during 1967, brown soft scale increased sharply in July and August in Rio Grande Valley, Tex., citrus groves. This was particularly apparent in several groves immediately north, or downwind, of cotton plantings.

c. Systemic Insecticides. At Riverside, Calif., 14 systemic insecticides were tested for control of spirea aphid, citrus thrips, and citrus red mite. Sweet orange seedlings in 1-gal pots received from 0.05 to .4 g actual toxicant applied to soil surface. Eight to 9 weeks after application, the highest dosage of Union Carbide UC-21149, disulfoton, dimethoate, demeton, schradan, Azodrin, and American Cyanamid CL-47031 produced control of the spirea aphid. Eleven weeks after application the highest dosage of UC-21149, Dansanit, dimethoate, Bay 37289, Azodrin, CL-47031, and phorate produced control of the citrus thrips. UC-21149 and schradan gave control of the citrus red mite for up to 28 weeks, Dansanit 32 weeks, and phorate 45 weeks. Disulfoton remained effective at 52 weeks with 85% mortality.

At Riverside, Calif., soil applications of UC-21149 were made to navel and valencia oranges and Lisbon lemon trees at 4.5 g active ingredient per tree in April 1966, 10 g in March 1967, 25.0 g per tree in Feb. 1968. Control of thrip larvae was 88 to 98% in the summer of 1967 compared to 35 to 100% in 1968. In 1967, 9 months after application, control of the citrus red mite was 0 to 90% compared to 97 to 100% in summer 1968. One month after the 1968 applications there was 93 to 97% reduction in terminals infested with citrus aphids. Trunk measurements of navel and valencia trees in December 1967 showed a slight increase in diameter over untreated controls. Lemon trees show slightly less growth than the controls.

UC-21149 applied as side dress treatment to mature navel orange trees at rates of 0.1 to 0.2 pound active ingredient per tree gave effective control of citrus red mite from 5 to 14 mos after application. During the first 5 months following application, control was inadequate, only 62% control being obtained with the higher dosage. At 14 months, 67 and 97% control was obtained at 0.1 and 0.2 pound dosages, respectively. After 15 months the higher dosage also became ineffective.

2. Subtropical Fruit

a. Screening New Insecticides. At Honolulu, Hawaii, 39 candidate

insecticides were evaluated topically and residually against fruit flies. Four experimental compounds were equal or superior to malathion in activity.

b. Insecticide-bait Sprays. At Honolulu, ten experimental materials combined with PIB-7 evaluated as bait spray deposits on guava foliage performed as well or better than the standard malathion. Carbofuran, Zectran, and Matacil were non-injurious to automobile finishes of acrylic lacquers and enamels.

At Honolulu, 2 protein hydrolysates, O.M. BHY (hydrolyzed blood protein) and O.M. HAP (hydrolyzed meat protein) were more attractive than the standards against both sexes of all 3 species of fruit fly.

In Hawaii, additional 1 mile² tests of undiluted PIB-7 plus technical malathion or naled in 19:1 ratios were applied at 15 oz/acre. Oriental fruit fly populations were reduced 75% and sterile medfly and melon fly populations were reduced 97 to 99%.

Malathion low volume concentrate at 1 oz/acre, with or without the addition of 8 oz of protein hydrolysate bait (PIB 7), effectively reduced Caribbean fruit fly populations in Miami, Fla., when applied to square-mile plots 3 times at weekly intervals during September. Malathion low volume concentrate at 1/2 oz plus PIB 7 at 8 oz/acre also reduced fly populations at this time of the year.

C. Biological Control (3.8 SMY)

1. Citrus

a. Parasites. Microterys flavus was the predominant parasite of brown soft scale during the year at Weslaco, Tex. During past years at most 5% of the parasites collected were M. flavus. This species became increasingly important this year. In January, February, and March, 55.4, 54.4, and 74.3%, respectively, of the parasites collected were of this species. Coccophagus lycimnia, which normally constitutes in excess of 90% of the parasites collected, dropped to 19.4% in March. Higher rainfall and humidity following the hurricane may be responsible for the increase in importance of M. flavus. Parasite levels also became higher than previously recorded. Some groves showed that 65% of the scale collected were parasitized in March.

Heavy parasitism of brown soft scale by Microterys flavus in the Vining Grove at Weslaco, Tex., led to studies indicating that scales from this grove are more susceptible to this parasite than other Rio Grande Valley scales, including the laboratory colony. Laboratory tests of comparative susceptibility showed that 30% of the Vining scale, 11% of the scale from the Guerra Grove in Roma, and none of the laboratory scale were parasitized when they were reared on citron melons and exposed to M. flavus. Brown soft scale obtained from heavily infested cotton at Brownsville, Tex.,

proved to be more susceptible. When this scale was transferred to citron melons and exposed to M. flavus, 100% of the scales were parasitized.

Observations on rearing Microterys flavus in the laboratory at Weslaco, Tex., revealed that the brown soft scale heavily encapsulates and melanizes foreign matter inserted in the scale body. The host defense mechanism appears to be the same when parasite eggs, glass wool fibers, or minutemadeln are inserted in the body. Encapsulation of the parasite egg begins at the point of entry and progresses down the egg stalk to the egg. A heavy deposition of melanin that usually accompanies the encapsulation appears to be the principle factor responsible for the mortality of the eggs.

Studies on the ovipositional behavior of Encyrtus lecaniorum, a parasite of brown soft scale, revealed that a parasite with a life span of 8 days deposited as many eggs as those with life spans of 13 days. The mean number of eggs deposited per parasitized scale ranged from 1.58 to 2.56. From 77.5 to 84.2% of the scale exposed to parasites were parasitized. The parasite with the shortest life span had the highest rate of parasitism.

Following release of the California red scale parasite, Aphytis melinus, in a citrus grove at Roma, Tex., a significant decline in population of this scale occurred. Parasites of this genus have been recovered from the grove one year after release but have not been positively identified as to species.

Black scale collected from lemon, grapefruit, mulberry, oleander, and natal plum were heavily parasitized with a parasite identified as Eunotus sp., family Pteromalidae, at Weslaco, Tex. This species was reported from Puerto Rico from this host in 1964. These are the first records of black scale on citrus in several years in this area. Black scale is of little economic significance in the Rio Grande Valley area and Eunotus sp. appears to be the principle parasite.

In May 1967, approximately 11,500 Metaphycus helvolus, an encyrtid parasite of black scale, were released in 4 major citrus growing areas of Florida by personnel of the Orlando, Fla., station. Recoveries were made up to 7 months after the introduction. However, subsequent monthly samples have been negative, indicating that the parasites failed to overwinter successfully. The indigenous predator, Scutellista cyanea, was found to be of significant importance in suppression of 2nd and 3rd generation scale populations but ineffective against 1st generation black scale, Cheiloneurus sp., an internal encyrtid parasite, was found parasitizing 2nd and 3rd stage, and an entomogenous chytrid was found attacking all stages of black scale. This is the first report of these natural enemies occurring on black scale in Florida.

b. Predators. Under a grant at the University of California, Riverside,

the use of supplemental foods to increase populations of mite predators is being investigated. Amblysicus hibisci (Chant) and A. limonicus Garman and McGregor were fed various combinations and proportions of sucrose, yeast hydrolysate, lipids, etc. Water solutions of high concentrations of these foods caused decreased oviposition over the pollen diet, apparently due to a lack of chemical gustatory properties for initiating feeding.

c. Pathogens. The noninclusion virus of the citrus red mite was evaluated in the field at Riverside, Calif. Introduction of field infected mites in large numbers from an epizootic was effective in establishing new epizootics. Virus sprays at 0.05 and 0.1% on citrus seedlings in greenhouses also were effective.

Viability of the citrus red mite virus at room temperature in intact mites almost equalled mites held in deep freeze. Laboratory studies on the influence of temperature and drying on the virus disease show that it can be resuspended after drying at room temperature and holding for periods of 0, 1/2, 1, 2, and 4 hours before resuspension.

Of 7 species of Tetranychid mites tested at Riverside, to determine susceptibility to citrus red mite virus disease, only Tetranychus telarius (Boisduval) developed birefringent crystals indicative of the virus disease.

At Riverside, a Model 1 D-Vac vacuum insect net was useful for studying the noninclusion virus disease infecting the citrus red mite, Panonychus citri (McGregor) when populations are very low. Fifteen of 21 groves sampled showed virus infection. Seven of these had not been detected by the standard procedure of picking 20-leaf samples by hand.

The parasitic fungus, Hirsutella thompsonii, was isolated from the citrus rust mite at Orlando, Fla. Maximum growth and sporulation of the fungus was obtained on potato dextrose agar and Sabouraud dextrose agar. Vegetative growth of H. thompsonii was excellent in a 1.5% yeast extract, 0.05% bacto peptone, 2% dextrose liquid medium with artificial aeration. Methods are being developed for mass producing the pathogen.

2. Subtropical Fruit

a. Parasites. Opius oophilus, the egg-larval fruit fly parasite, continued to dominate parasite recoveries in Hawaii. High parasitism, especially by oophilus, occurred in litche, Jocote corona, coffee, loquat and rose apple. Opius tryoni and Opius fletcheri, parasites of the medfly and melon fly, respectively, continued to be recovered in fair numbers. O. tryoni and O. fletcheri were believed to be ineffective at one time.

At Hilo, Hawaii, it was determined that parasitized and unparasitized fruit fly pupae can be differentiated beginning 2-3 days after pupation. Distinguishing characteristics (by microscopic examination of puape through

transmitted light) are the formation of the 3 body regions (head, thorax, and abdomen) 36-72 hours after pupation while the parasitized pupae are larva-form in structure. The segregation of parasites and flies before their emergences lessens the workload of later separation after emergences and also lessens the chances of injury or mortality to the adults caused by handling.

D. Insect Sterility, Attractants, and Other New Approaches to Control
(6.6 SMY)

1. Citrus

a. Sex Pheromones. California red scale, Aonidiella aurantii (Maskell), are being reared at Riverside, Calif., for sex pheromone research in large numbers on green lemons and on White Rose potatoes. Virgin females reared on potatoes produced sex pheromone essentially equal in attractiveness to those reared on lemons. However, females on lemons began producing pheromone 5 days earlier and continued for a longer period of time.

Studies of flight pattern of male California red scale were made at Riverside, using traps baited with virgin red scale females placed in lemon trees. Counts showed a distinct male flight peak just before or after sunset. Males were collected when late afternoon temperatures ranged from 86 down to 60° F. Light measurements show that peaks of male flight usually occurred while light was decreasing from approximately 200 down to 15 ft. Males were present when humidities ranged from 20 to 65%. Over twice as many males were captured in traps at heights of 8 and 12 feet as at 4 feet, indicating that traps for red scale field collections should be placed in the upper parts of the trees.

A small trap for field collection of California red scale males was developed. Red scale males were marked with Calco-oil dye and released in a mature orange grove. Tanglefoot-coated cards (3"x5") on 1-pint ice cream cartons baited with virgin females and placed in concentric circles around the scale release point trapped males 300 feet upwind and 620 feet downwind from the release point.

2. Subtropical Fruit

a. Sterilization Techniques. At Honolulu, Hawaii, complete dominant lethality was not obtained in medfly males irradiated at a dosage of 10.7 ± 0.7 kr 1 day before, 1 day after, or 2 days after emergence. Approximately 0.1 to 0.2% of eggs laid by normal females crossed with irradiated males hatched. More eggs were laid by females irradiated as adults than by those treated as 9-day old pupae. Eggs laid by irradiated females crossed with normal males did not hatch.

At Hilo, Hawaii, Mediterranean fruit flies irradiated at 10 kr as pupae were slower to respond to female overtures than normal males. This delay

of 1 to 2 hours would handicap them in mixed populations when females wanting to mate would be diverted to the more aggressive or responsive, normal males.

Longevity of melon flies was affected adversely by irradiation to a greater extent than by chemosterilization with tepa. Normal male and female melon flies lived 58 and 54 days, respectively, before there was 50% mortality in the population; chemosterilized flies 52 and 53 days; and radiation-sterilized flies 38 and 33 days.

At Honolulu, 4 sterile releases of equal numbers of the dark and normal melon fly strains were made to compare longevity of the sterilized flies in the field. Trap recoveries from 54 cue-lure baited traps showed that the 2 strains were recovered in about equal numbers over the same period of time. Fifty-eight percent of the recaptured marked flies were taken more than 0.5 mile from the release site.

At Honolulu, low-cost paper bags and cardboard boxes were compared as aerial release containers for release of sterilized melon and Mediterranean fruit flies. At a loading rate of 3,000 pupae per container, bags containing X-shaped cardboard inserts, with sugar cubes as food, were superior to bags with excelsior and equal to the cardboard boxes. Water was not necessary as long as the flies were released within 2 days of emergence.

b. Sex Pheromones. At Hilo, released sexually mature, virgin Mediterranean fruit fly females were attracted in large numbers to live mature males enclosed in Steiner plastic traps. Native populations of Mediterranean fruit fly in the area had been completely displaced by the oriental fruit fly. Of 4,460 females released, 24% were recovered within 6 hours (1 female 1,000 feet away in 4 hours) and 40.3% within 4 days. One male per trap was as attractive as trimedlure, 5 males caught 3 times as many, and 25 sterile males 13 times as many as 1 sterile male. Sterile males were as attractive as normal males to females the first day. Thereafter, sterile males attracted 60% less than normal males. In tests where wild populations of Mediterranean fruit fly existed, the presence of mature males in the traps failed to capture any females.

c. Chemical Lures. At Honolulu, 66 candidate lures were evaluated in an olfactometer against adult fruit flies. Four were very attractive to the Mediterranean fruit flies in the liquid in glass traps but were only slightly so when tested on wicks.

Twelve of 14 fractions of angelica seed oil were found to show attraction in varying degrees to the male Mediterranean fruit fly.

At Honolulu, the approximate threshold concentration of methyl eugenol, trimedlure, or cue-lure for fly response in olfactometer wick tests was estimated by exposing lure concentrations ranging from 500 mg to 0.5

nanogram on 3/8x1/4 inch cotton wicks. Under olfactometer conditions the threshold concentration for attraction was within the range of 5 to 50 ng for oriental fruit flies, Mediterranean fruit flies, and melon flies for each attractant, respectively.

At Honolulu, Hawaii, it was found that male dark strain melon flies were as responsive to cue-lure as the normal (light colored) laboratory flies. Of an estimated 5,000 males of each strain, 2,316 dark and 2,639 normal males responded to cue-lure in the olfactometer. Male melon flies did not respond to cue-lure for the first 3 days after emergence; there was a slight response only the 4th day and a very strong attraction after the 5th day.

At Hilo, sexually mature virgin melon fly females responded to cue-lure in plastic traps only when they were starved in large out-door cage tests. In similar tests, sexually mature virgin females of the oriental and Mediterranean fruit flies responded to their respective lures (methyl eugenol and trimedlure) when food was provided and available to the flies. These responses occur only in the absence or scarcity of mature male flies.

d. Male Annihilation Techniques. In Hawaii, Thixcin E was superior to CAB-0-SIL and monoglyceride of lard as a thixotrope for preparing viscous male lure plus toxicant formulations for airplane distribution in male-annihilation programs. The shearing action of a blender is sufficient to disperse the Thixcin E in fruit fly lures to produce mixtures of the proper consistency without the use of heat.

At Honolulu, 4 musk chemicals extended the effectiveness of trimedlure for 1 week or longer but did not improve the effectiveness of medlure.

In a 2-mile² plot near Hilo, fiberboard bait stations saturated with naled in cue-lure reduced the male population 99%. In one 15-acre area, sterile flies survived at least 66 days after emergence, suggesting that the lure may be unattractive to some flies.

At Hilo, 4 ml of trimedlure on a 5/8" diameter wick in the center of a fiberboard wafer treated with naled caught 3 times as many Mediterranean fruit flies as a fiberboard bait station saturated with a solution of naled in trimedlure. The "wick-wafer" used only 1/7th as much lure but required 8 times as much insecticide. The "wick-wafer" provides flies with an acceptable but lethal resting surface near the lure source which the completely lure-treated wafer does not provide.

E. Evaluation of Equipment for Insect Detection and Control (0.5 SMY)

1. Subtropical Fruit

a. Traps for Survey and Detection. In Hawaii various modifications of

the standard plastic trap baited with trimedlure were tested. Catches of Mediterranean fruit flies were reduced 72% by substitution of 1% naled in the lure for lindane-chlordane (LC) powder in the bottom of the trap; 21% using both naled and the LC powder; 55% by confining the wick in an open end glass tube to reduce volatilization and, 34% by using fiber squares saturated with lure. An Israeli trap with a bottle designed to save lure caught 59% less flies than the standard when it contained DDVP and 35% less when the LC powder was used. As many as 100 flies were attracted but paused for 1 or more hours on adjacent foliage and exterior of high lure-output traps compared to low output traps. With a slight decline in temperature in the late afternoon, most flies left the foliage and entered the nearest trap.

In Hawaii, studies to assess the efficiency of various types of fruit fly traps showed that sticky traps performed significantly better than the standard plastic medfly trap in catching wild medflies. When medflies approach trimedlure in standard traps, many alight on foliage nearby or on the outside of the trap and are slow to enter. Sticky traps take advantage of this behavior by providing a sticky surface near the lure to hold the flies when they alight.

Cue-lure, in clear plastic traps, operated more effectively as an attractant for the male melon fly when the traps were hung at 1/10 foot or less than 6 feet above ground level than when placed between 6 and 15 feet. Cue-lure on fiberboard squares 3 feet above ground level was superior to squares placed on bare soil.

F. Insect Control Treatments for Commodities Regulated by Plant Quarantine (2.4 SMY)

1. Subtropical Fruit

a. Fumigation Treatments. At Honolulu, combinations of methyl bromide with post-treatment refrigeration treatments were tested for control of the Mediterranean fruit fly, *Ceratitis capitata* and the oriental fruit fly, *Dacus dorsalis*, in papayas and oranges in corrugated fiberboard cartons or field boxes. Fumigation at the dosage of 2 lb/1,000 ft³ for 2 hrs at 70° F required refrigeration for 11 days at 45° F or 3 days at 35° F. Fumigation at the dosage of 2 lb/1,000 ft³ for 2.5 hrs at 70° F required refrigeration for 4 days at 37° F, 6 days at 45° F, or 10 days at 55° F. Fumigation at the dosage of 2 lb/1,000 ft³ for 3 hrs at 70° F required refrigeration period of 3 days at 45° F and 6 days at 55° F.

In Hawaii, J. C. Carter #1 avocados tolerated fumigation with methyl bromide at the dosage of 2 lb/1,000 ft³ for 2.5 hrs at 70° F and post-treatment storage at 45° F for 6 days.

At Honolulu, 20-min dip treatment in water at 118° F, before or after fumigation with methyl bromide at the dosage of 1 lb/1,000 ft³ for 2 hours

at 70° F, increased the mortality of oriental fruit fly, D. dorsalis, eggs and larvae in fumigated papayas from 88 to 99%. The mortality of melon fly, D. cucurbitae, larvae in fumigated papayas was not increased significantly by the dip treatments.

Tolerance tests were conducted on papayas given the hot water treatment to control decay organisms and then cooled before fumigation with methyl bromide at the dosage of 2 lb/1,000 ft³ for 3 hrs at 70° F and post-treatment refrigeration at 55° F for 6 days. The number of decayed fruits appeared to increase with the stage of coloring when treated. The marketable period at temperatures about 80° F was 2.3 to 3.9 days for fumigated fruits and 2.6 to 5.1 days for untreated fruits. Refrigeration at 45° F scalded both untreated and treated fruits.

At Hoboken, N.J., 6-hour fumigations with ethylene oxide, in combination with carbon dioxide or freon, gave complete kill of nonestivating snails but not of estivating ones.

b. Modified Atmosphere. At Honolulu, mortality of D. dorsalis eggs and larvae in papayas was 82% when fruits were stored in a modified atmosphere containing 0.2 to 1.2% oxygen and 13% carbon dioxide for 5 days at 55° F. Mortality was 60% when the oxygen concentration was 5% and the carbon dioxide concentration was 11%, and 72% when the oxygen concentration was 15% and the carbon dioxide concentration was 3 to 5%.

c. Vapor Heat. At Honolulu, Burpee cucumbers and N-52 tomatoes did not tolerate quick run-up vapor heat treatment. Surface pitting was observed in 80% of the cucumbers and aroma and flavor were less characteristic. The treated cucumbers were spongy, resulting from the separation of the carpels. The flavor and aroma of treated tomatoes were reduced, seeds were darkened, and the texture of the pulp was grainy.

d. Gamma Radiation. At Honolulu, minimum doses of gamma radiation in the Hawaii Development Irradiator required to prevent the development of adults from eggs and larvae of Dacus dorsalis Hendel was found to vary with the bulk density of papayas in the cartons. The mean minimum dose was 25.3 and 29.0 kr when the bulk density was 22.0 and 24.6 lb/ft³, respectively. The minimum dose of 22.2 kr was not sufficient to prevent adult emergence when the bulk density was 24.1 lb/ft³. The minimum dose of about 24 kr of gamma radiation appeared to kill the eggs, larvae, and pupae of the mango weevil in limited tests. A larva survived when the irradiated mangoes were refrigerated at 45° F for 5 days, but the larva was weak and died within 24 hours. There were no survivors from mangoes absorbing minimum dosages of 30.1 to 34.5 kr. The bulk densities of the cartons with mangoes were 27.8 to 33.6 lb/ft³.

RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

A. Insect Vectors of Diseases (1.3 SMY)

1. Citrus

a. Tristeza. Increasing numbers of melon aphids above 200 per test plant did not result in greater transmission of tristeza virus to Key lime seedlings at Orlando, Fla. Tests using 200, 400, or 800 aphids per plant gave transmission rates of 20.5, 23.0, and 20.5%, respectively, in 83 test plants per series.

b. Exocortis. Exocortis virus was transmitted to one Etrog citron out of 6 when lubber grasshoppers were allowed to feed on an exocortis-infected Etrog citron plant then transferred to healthy plants at Orlando, Fla. Symptoms of exocortis appeared after 134 days.

c. Stubborn. Tests have been undertaken at Riverside, Calif., to determine if there is an insect vector of stubborn disease of citrus in parts of the U.S. where this disease apparently is spreading naturally. Tests have shown that several species of psyllids feeding on plants in or near citrus will feed on citrus and survive for up to 4 weeks. Two species of psyllids, the potato or tomato psyllid, Paratriozza cockerelli, and an Acacia psyllid, Psylla uncataoides, are being tested as vectors. Greenhouse grown Duncan grapefruit or Madam Vinous sweet orange variety are being used as indicator plants. Successful transmission would be expected to become apparent in 3 months to 1 year.

RPA 701 - INSURE FOOD PRODUCTS FREE FROM TOXIC RESIDUES FROM AGRICULTURAL SOURCES

A. Fumigant Residue Determinations (0.5 SMY)

1. Papayas

At Honolulu, total bromides were determined in papayas packaged in cartons, fumigated with methyl bromide at the dose of 2 lb/1,000 ft³ for 3 hours at 70° F and refrigerated at 55° F. Residues were 11.3 ± 1.1 ppm and 13.1 ± 0.9 ppm when the fruits were analyzed on 1 and 3 days after treatment respectively. Residues were 17.5 ± 1.3 ppm and 15.0 ± 1.3 ppm when fumigated at the dosage of 4 lb/1,000 ft³ for 3 hours at 70° F.

Total bromide residues in papayas were 368 ± 36 ppm at 2 hours, 236 ± 40 ppm at 1 day, and 66 ± 6 ppm at 3 days after treatment in corrugated fiberboard cartons with EDB at the dosage of 24 oz/1,000 ft³ for 2 hours at 70° F. Residues in the shredded newspaper used in the cartons were 513 ± 2 ppm, 211 ± 28 ppm, and 58 ± 8 ppm, respectively. Residues in single-faced corrugated fiberboard liners for pineapples in field boxes were 136 ± 11 ppm, 71 ± 8 ppm, and 40 ± 5 ppm on 2 hours, 1 day, and 3 days, respectively, after treatment at the dosage of 12 oz/1,000 ft³ for 3 hours at 70° F.

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RPA 205 - CONTROL OF DISEASES OF FRUIT AND VEGETABLE CROPS

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ORNAMENTAL, SHRUB, FLOWER, AND TURF INSECTS

Entomology Research Division, ARS

RPA 906 - CULTURE AND PROTECTION OF ORNAMENTALS AND TURF

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968
New Jersey	3.8
New York	2.0
Maryland (Beltsville)	.7
Washington	1.0
Total	7.5

Problems and Objectives

Annual losses to outdoor ornamental plants by aphids, borers, cutworms, mealybugs, scales, spider mites, and other pests are estimated to be nearly three-quarters of a billion dollars. These losses result from feeding damage and/or diseases which are insect transmitted. In addition, these insects cause an estimated \$80 million damage to horticultural specialty crops grown commercially in greenhouses and nurseries. Insect and mite resistance to pesticides has resulted in increased damage in recent years. The practice of florists depending on a few establishments for cuttings of young plants, such as chrysanthemums, carnations, geraniums, and roses, often results in the inadvertent distribution of pests to many areas and excessive losses before control measures can be applied.

Major objectives of the research on methods to control ornamental and turf insects are to utilize:

1. Information on the biology, ecology, and population dynamics in developing control practices.
2. New and selective insecticides.
3. Resistant varieties.
4. New approaches such as sterility, attractants, repellents, and biotic agents.

Progress - USDA and Cooperative Programs

A. Basic Biology, Physiology and Nutrition (1.3 SMY)

1. Ornamentals

a. Greenhouse whitefly. At Beltsville, Md., the developmental life cycle from egg to adult eclosion in growth chambers was determined to be 36 days at 60° F, 23 days at 80° F, and 31 days under greenhouse conditions of 65° night and 85° day temperatures. Eggs hatched in 6 days at 80° F, 12 days at 60° F in growth chambers, and 10-11 days in the greenhouse. Young nymphs and newly emerged adults are more susceptible than other stages to insecticides.

b. Flower thrips. The migration peaks occurred at Ft. Valley, Ga., from May 24 to 29; at Beltsville, Md., from June 22 to July 3; and at Farmingdale, N. Y., during the second week of July. Populations were highest at Ft. Valley, intermediate at Beltsville, and lowest at Farmingdale.

c. Miscellaneous insect pests. At Beltsville, Md., new insect pest distribution and new host damage were recorded as follows:

A whitefly, probably A. spiraeoides, known previously only from Florida, was abundant on bearded iris in Washington, D.C.

The strawberry whitefly, Trialeurodes packardi, considered a minor pest of strawberry and other hosts, severely damaged mockorange and honeysuckle in Elkland, Pa.

The apple maggot, Rhagoletis pomonella, reared from berries of Pyracantha lalandi from Mickleton, N.J., has been previously found damaging this host only from Texas.

The Florida flower thrips, Frankliniell bispinosa, known previously only from Florida and coastal areas in Alabama and South Carolina, was collected on sticky cards at Fort Valley, Ga.

At the University of Georgia under a research grant, bagworm eggs collected in November 1966 and stored at 8° C for various periods up to 11 months and 9 days continued to hatch but none hatched after longer storage. Eggs collected in March 1967 failed to hatch after a cold storage of more than 7 months.

Number of bags on 2 trees increased from 34 in 1966 to 1542 in 1967 or at a ratio of 45:1. An increase of 20 to 1 was found in sampling a larger infestation. Current year's bags contained dead larvae or pupae due to parasites or disease so the expected increase in 1968 would be much less than 20 to 1.

2. Lawns and Turf

a. Japanese beetle. In studies at Moorestown, N.J., 14 to 37% of Japanese beetle eggs hatched and larvae reached the pupal stage after incubation in grass-seeded plastic pans containing soil mixtures of top soil, peat, sand, and vermiculite. Mature 3rd-instar larvae were obtained in 82-100 days. Continuing progress has been made at Moorestown, using a larval diet based on an acetone powder of grass. When 3rd-instar larvae were allowed to feed on the diet, 61% prepupated and 39% became adults. Incubation of Japanese beetle ova at Moorestown, in a 2:1 mixture of Michigan peat and sassafras sandy loam soil containing 1% redtop-white clover for food yielded 59% 3rd-instars and 16% adults. This media is currently being used in a large-scale rearing program designed to furnish 25 to 30,000 3rd-instar larvae.

b. European chafer. Adult European chafers in Geneva, N.Y., emerged from soil when light intensities at dusk had dropped to 30 foot candles and settled in trees when intensities had fallen to 1.25-1.0 foot candles.

B. Insecticidal and Cultural Control (2.3 SMY)

1. Ornamentals

a. Aphids and mites. At Sumner, Wash., 1% lindane dust at 4 pounds active ingredients per acre in the furrow effectively controlled tulip

bulb aphid on stored iris bulbs 74 days after harvest. Complete kill of tulip bulb aphids on stored iris bulbs was obtained in 1 week in a growth retarding chamber when resin strips (10 x 2½ in) containing 20% dichlorvos were distributed at the rate of 1 or 2 per 1000 cubic feet. Tulip bulb aphids were also controlled on dormant iris bulbs by exposure to 95° F for 10 days or 100° F for 7 hours without damage to the iris bulbs.

In decreasing order of effectiveness Union Carbide UC 21149 applied as Temik, disulfoton, phorate, Niagara NIA-10242, and oxydemetonmethyl controlled crescent marked lily aphids on greenhouse-forced Easter lilies when applied at 4 pounds active ingredient per acre of granules to the soil surface of potted lily plants 3 to 5 inches high.

At Farmingdale, N.Y., a species of Rhizoglyphus mite was found feeding on bruised Easter lily bulb scales and on roots where bulb rots were present. Extensive feeding also occurred on apparently healthy roots and bulbs. Root tip injury was reduced by soil applications of demeton and UC-21149 applied as Temik at rates of 20 lb active/acre, but 7 other materials were less effective.

At Farmingdale, UC-21149 applied to the soil of potted rose plants killed aphids and spider mites for 2 months or longer.

Dimethoate, carbofuran, phorate, and UC-21149 applied to the soil were tolerated by poinsettia cultivars but only UC-21149 controlled a recently recognized highly resistant strain of spider mites. Azodrin was nontoxic to foliage but disrupted color development in the bracts. Formetanate and Dowco-213 caused no injury to foliage and applied as foliage sprays controlled the new resistant mites.

b. Narcissus bulb fly. At Sumner, Wash., 10% phorate granules at 2 pounds active ingredient per acre in furrow application was as effective in controlling narcissus bulb fly as the standard 10 minute heptachlor soak.

c. Vegetable leafminer. At Beltsville, Md., dichlorvos impregnated corn cobs released vapors which were toxic to vegetable leafminer adults for 12 days. Residues in plants exposed to vapors were toxic to adults for 2 hours after removal but not for 24 hours. Leafminer eggs and larvae were more readily killed by dichlorvos in resistant chrysanthemum cultivars than in susceptible ones.

d. Omnivorous leaf roller. At Beltsville, Md., methomyl and Azodrin effectively controlled omnivorous leaf roller larvae on greenhouse roses. Slightly less effective but equal to Zectran were Matacil, trichlorfon, and Bacillus thuringiensis. Of 9 insecticides tested Zectran, carbaryl, Matacil, Azodrin, and Gardona were still highly toxic 3 and 7 days after treatment.

e. Scale insects. At Beltsville, Md., carbofuran, Bidrin, and azinphos-methyl gave effective control of 2nd- and 3rd-instar Florida wax scale. Summer oil-ethion mixture also gave good control but caused defoliation.

At Beltsville, Md., applications of dimethoate or ethion-summer oil sprays in August against nearly mature scales or in early spring against younger scales gave effective control of tulip tree scale.

2. Lawns and Turf

a. Japanese beetle. In laboratory tests at Moorestown, N.J., azinphos-methyl, carbaryl-Pinogel, dimethoate, naled, carbaryl, and trichlorfon gave 90-100% kill of Japanese beetle adults with a dosage of less than 1 mg. In field-weathering tests, carbaryl at 8 oz/acre was the most persistent on foliage, giving 90-100% control for 10 days after application.

b. European chafer. Applications of several dosage levels of finely divided carbaryl and DDT dust were made in surrogate transportation vehicles in Geneva, N.Y. DDT and carbaryl at 1 g/1000 ft³ were deemed most practical. Both materials were toxic to both species within 2 hours and DDT caused the deaths of all Japanese beetle and European chafer adults in 24 and 48+ hours, respectively, after treatment. Carbaryl was also effective against adults of both species, but required longer than 48 hours for complete kill.

A number of materials were studied at Geneva, N.Y., in an effort to find a substitute for chlorinated hydrocarbon insecticides for grub control. Two of these experimental materials satisfactorily controlled first-instar European chafer larvae for 9-12 weeks. Control was not satisfactory with either material after 15 months.

C. Insecticide Sterility and Persistence (.1 SMY)

1. Ornamentals. At Beltsville, Md., dichlorvos impregnated on granules of corn cobs or vermiculite in 1962 remained toxic to insects for at least 6 years. Chemical analysis indicated that 2.2 to 9% of the dichlorvos was retained at the end of this period.

2. Lawns and Turf. Residues of chlordane and DDT from Japanese beetle control soil treatments applied in 1948 at Moorestown, N.J., were determined by gas chromatography. No residues of chlordane were detected from plots treated with 11 or 19 lb/acre. Where DDT was applied at 25 and 60 lb/acre, however, residues of 6.6 and 12.7 ppm were obtained. These amounts are about 1/4 and 1/3, respectively, of the amounts determined by analysis 2 years after application.

D. Biological Control (1.0 SMY)

1. Lawns and Turf.

a. Japanese beetle. Spores of Bacillus popilliae produced on artificial medium by the Northern Utilization laboratory at Peoria, Illinois, were fed to Japanese beetle larvae in tests at Moorestown, N.J. When fed a dose containing 2.8×10^5 spores obtained from diseased grubs, 62% of the test larvae became infected. No larvae became infected when fed a similar dose of spores produced on artificial medium.

E. Insect Sterility, Attractants, and Other New Approaches to Control
(2.5 SMY)

1. Ornamentals

a. Bagworm. In studies under a grant to the University of Georgia, the pheromone produced by female bagworm moths was attractive to males in field tests. Males were trapped in a pheromone baited trap in preference to unbaited traps.

2. Lawns and Turf.

a. Japanese beetle. In replicated field tests conducted by personnel of the Moorestown, N.J., laboratory at Lumpkin County, Ga., with 88 candidate lures, ENT-14189 + eugenol, 9:1, captured 2.5 times as many beetles as the standard (phenylethyl butyrate + eugenol, 9:1). In field tests carried out on Nantucket Island, Mass., by personnel of the Moorestown station, traps baited with phenylethyl butyrate mixed with an equal amount of Solvasol 35 caught 35 beetles/trap as compared to 18 beetles/trap captured with phenylethyl butyrate + eugenol (9:1) the standard bait.

In tests at Moorestown, N.J., ova were collected from females confined in 125 ft³ cages with different ratios of tepa-sterilized to fertile male beetles. The percent sterility of these ova generally tended to reflect the proportional numbers of sterile to fertile males in the cages, thus indicating equal mating competitiveness of the treated males.

b. European chafer. Of 235 lures screened at Geneva, N.Y., for attractancy to the European chafer, ENT-26,035 and ENT-33,181, were 3.0 and 1.8 times more attractive, respectively, than the standard, butyl sorbate.

The attractancy of virgin female European chafer adults was demonstrated for the first time at Geneva, N.Y. In preliminary tests, the virgin females were slightly more attractive than the standard bait when exposed in black chafer bucket traps.

F. Evaluation of Equipment for Insect Detection and Control (0.1 SMY)

1. Lawns and Turf. In tests conducted at Geneva, N.Y., baited red plastic survey traps captured 1.2 - 15 times more European chafers than did baited black standard traps.

G. Insect Vectors of Diseases (.2 SMY)

I. Ornamentals. In tests at Beltsville, Md., the green peach aphid transmitted tomato aspermy virus (TAV) and alfalfa mosaic virus (AMV) to Tephrosia and Vernonia and cucumber mosaic virus (CMV) to Vernonia and Limnanthes. These viruses were also transmitted mechanically to the same hosts. CMV and bean yellow mosaic virus (BYMV) were transmitted mechanically to kenaf and Limnanthes. All of these viruses produced systemic infections in their respective hosts. Only local infection followed mechanical inoculations of TAV to kenaf and Limnanthes. No infections resulted from aphid or mechanical inoculations of potato virus Y (PVY) in any of the four hosts or of BYMV in kenaf, Limnanthes or Vernonia. The results indicate that virus infection by the common and widespread viruses CMV, TAV, AMV, and BYMV are a greater threat to Tephrosia and Vernonia crops than to kenaf or Limnanthes. None of these crops appear susceptible to PVY. Kenaf is a new source of paper pulp; Tephrosia contains rotenone; Limnanthes and Vernonia seed contain oils used in plasticizers.

Publications - USDA and Cooperative Program

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CONTROL OF INSECT PESTS OF FRUIT AND VEGETABLE CROPS
RPA 204

Agricultural Engineering Research Division, ARS

USDA and Cooperative Programs

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Arizona (Tucson)	Vegetables	1.0
California (Riverside)	Vegetables	1.0
Georgia (Albany)	Pecans	-
Indiana (Lafayette)	Peaches	Grant
Indiana (Lafayette)	Vegetables	0.5
Maryland (Beltsville)	Spray studies	1.1
Mississippi (State College)	Spray studies	Contract
Ohio (Wooster)	Vegetables	1.6
Oregon (Forest Grove)	Spray studies	0.8
Oregon (Forest Grove)	Vegetables	0.2
Washington (Yakima)	Apples	2.0
	Total	8.2
Israel (Rehovot)	Spray studies	PL-480

Intramural program is supplemented by extramural support representing (a) 2.6 SMY's at State Agricultural Experiment Stations, (b) 0.0 SMY's at other U.S. institutions and (c) PL-480 funds in one country representing \$14,700 U.S. dollars equivalent.

Problems and Objectives

Successful commercial production of most fruit and vegetable crops requires expensive inputs to control the ravages of insect pests. Chemical pesticides have provided a defensive method for growers to obtain control, but many chemicals have gradually lost their effectiveness as the insect populations developed resistance or tolerance. This situation and increasing concern about pesticide residues on food items and in the general environment indicate that research should be directed toward reducing the amount of toxic material applied and toward replacement of chemical control with other methods of repelling or destroying insect pests.

Engineering objectives of the research program are:

1. To improve deposition efficiency of chemical sprays, thereby reducing the total amount of toxic material applied.
2. To improve non-spray methods of applying chemicals.
3. To determine the influence of electromagnetic radiation of all wavelengths on repelling or attracting insects.
4. To develop electric equipment for attracting and destroying insect pests.

Progress - USDA and Cooperative Programs

A. Spray Studies

At Beltsville, Maryland, engineers developed an electrostatic boom for use on a Cessna 180 plane to include 1065 tube openings .0135 inches in diameter and a copper charge bar 1-1/2 inches from the tubes. When spraying at 40 lb. psi, the static charge of 25 KV did not influence the discharge rate.

A screw-worm box ejector was modified and over one million sterile *Drosophila* flies were released from an airplane for native fly control on tomatoes. Information was gained for a more suitable fly ejector device.

A reduction in labor in the removal of tops and suckers from tobacco plants may be possible with foam inhibitors. From a series of foaming solutions tested, three appear promising as carriers of growth inhibitors. In laboratory tests, ClO alcohol controlled flowering and sucker growth on tobacco plants.

Contract research at State College, Mississippi, has shown that trajectories of particles released from an aircraft show wingtip vortices exert significant influence only on the path of small particles less than 500 micron diameter. This is true when aircraft altitude is at a minimum safe flight, and provided the particles are released at a point on the wing outside the core region of the tip vortex. A computer program is being modified to

compare experimental trajectory and theoretical wingtip vortex data to develop empirical relationships. This will provide an easier rapid method of particle trajectory for deposition on crops. A wind tunnel was developed for studying the dynamics of liquid droplets in flight.

A theoretical analysis in mechanics of solid materials dispersed from aircraft by pneumatic spreaders yielded two sets of equations. The equations are being verified by simulated tests. Valid equations will provide a means for a more effective design of applicators.

Helicopter spray systems for virus and carrier solutions were developed at Forest Grove, Oregon, and tested on Douglas Fir-Tussock moth larvae. Drop-let sizes were 106 and 230 microns mm^3 . Twenty-one-day bioassays on sprayed forest trees gave about 50 percent mortality, reaching 95 percent mortalities after 50 days. Helicopter releases of boxed sterile codling moths gave seasonal control of apple damage equal to normal spray programs at Yakima, Washington. Sterile to wild male ratio was 62:1 for releases over a 90-acre orchard between May and September.

A viscous materials pump has been developed for lure-toxicants for fruit flies. Tests will be run in Hawaii with equipment designed to fit leased Cessna aircraft.

A motor has been bench-tested and found suitable for the Bals spinning nozzle. Field tests are needed to determine the life of the unit.

A preventive spray program using helicopters on broccoli was tried for the second year against cabbage looper. Selected chemicals were applied on a ten-day program using ten and 15 gpa sprays. Chemicals used were DDT ester, parathion, phosdrin and TEPP. After seven treatments between August 9 and October 2, inspection of harvest at processing plant showed no damage to the crop, showing the success of the planned treatment.

B. Apples

At Yakima, Washington, the task of separating codling moth pupae, male from female, by size differences was improved with a machine modified to make 10 separate divisions. Using male insects separately is more effective than mixed sex in the sterile release program for controlling native infestations. Reflectance of codling moth pupa was greater in the infrared wave length (1.1 nanometers) than shorter wave lengths for separating only mature pupa. Only by using mature pupae when sterilized by irradiation can optimum vigor be maintained.

A flight mill was developed as a research tool to record flight time and distance for determining flight vigor of insects treated or reared differently. An insect trap suitable for use in remote areas without electric power was developed to collect insects in separate containers hourly for 28 hours without service. This provides a means of monitoring insect flight habits, population trends and species for efficient effective

control measures. Green peach aphid flight last season was mainly early and late daylight hours. Maximum flights were in May and August into September. Over 40 identified insect species were caught in the trap. An experimental pump and cone disc dispenser developed for ULV application produced seven to eight times more chemical (59 percent of the material) lay down eight inches above the row compared to a pressure nozzle using low or high liquid flow rate.

Tests of response of caged codling moths to blacklight ultra-violet radiation indicated over 50 percent attraction the first night and 70 percent or more the second night. Studies of the effect of light on diapause were initiated but results were inconclusive.

C. Peaches

Grant-supported research at Lafayette, Indiana, included tests of aphid locomotory responses to electromagnetic radiation from 350 nm wavelength to 700 nm, using a small, 12 inch x 3 inch, pentagonal test arena. Adult apterous aphids exhibited a gradual decrease in response to a monochromatic diffused light source as wavelength increased. When apterous and alate aphids were given a choice between diffused monochromatic light and diffused "white" light from a clear tungsten lamp, a sudden reversal of preference from monochromatic light to "white" light occurred for wavelengths of 600 nm and longer. This appears to agree with general observations that orange is attractive to aphids. In further tests infrared was filtered from the tungsten energy and no difference in response was noted between tests with, or without infrared energy. Similar tests were made using wavelengths from 450 nm to 600 nm with aphids of different ages, including first-instar nymphs and seven age groups of adult apterae from one to nineteen days after final molt. No significant differences were apparent in the adults, but the nymphs were more responsive than adults at each wavelength.

D. Pecans

A light-trap experiment was begun at Albany, Georgia, in an isolated eight-acre pecan grove using 33 traps with single 15-watt BL lamps. Hickory shuckworms were the only important pecan insects captured. Monitor traps outside the orchard on all four sides caught only 59 shuckworm moths, indicating no migration. Shuckworm infestation in shucks averaged only 14.6 percent in the lighted grove with a nut crop average over 50 lbs/tree. Flight activity of female shuckworm moths was found to be greatest about one hour after sunset, with male flight increasing rapidly at the same time but continuing at a high level two to three hours longer.

E. Vegetables

A field trial of blacklight insect traps baited with sex pheromone of the cabbage looper, Trichoplusia ni (Hubner), was begun on a lettuce-producing

ranch near Red Rock, Arizona. The ranch includes 2240 tillable acres divided into nominal 80-acre fields. A total of 415 trap locations are spaced at 330 feet intervals around the perimeters of these fields. An unlighted check area is located eight miles away near Picacho, Arizona. Trap collections, larval counts and egg counts of cabbage loopers, cotton bollworms, salt marsh caterpillars and beet armyworms are being analyzed to evaluate the degree of insect control achieved. Trapping began in February 1967. During the first season equipment functioned satisfactorily and unexpectedly large numbers of insects were caught. Ratios of male catches to female catches for the cabbage looper were high in both locations, indicating influence of the pheromone, but ratios of males to females were higher at Picacho than at Red Rock during population peaks. The grower applied usual amounts of insecticides in both areas and insect populations remained low. Additional data must be accumulated for adequate evaluation.

Tests of screen-cage traps, electrocutor grid traps, and light traps at Riverside, California, indicated that light is not essential to catch large numbers of male cabbage loopers in traps baited with synthetic sex pheromone. Traps using only the sex pheromone as an attractant catch almost exclusively male cabbage loopers, which simplifies counting and identification in survey-type applications. Catches of male loopers in screen traps were similar to catches in light traps baited with pheromone. Electrocutor grids also proved effective as killing devices for pheromone traps. Selection of a proper basis for comparing such different devices is difficult.

Two improved pheromone dispensers were developed: One uses a wick in a reservoir and remains attractive for three months; in the other the pheromone is sealed in a polyethylene bag and diffuses through the walls. The bag initially is as attractive as any other dispenser but attractiveness decreases with time, similar to jars with sand used last year. Caged male cabbage loopers responded to the pheromone at least 300 feet downwind from the pheromone source. Tests with traps at various densities indicated the need for evaluating interaction effects on trap catches in large areas. Increasing the density of traps does not proportionately increase the number of insects caught.

Use of light traps alone and of light traps plus insecticide has been compared at Lafayette, Indiana, for two years for protection of short-season hybrid cucumbers grown for pickling. Results show no real differences in insect damage, beetle population, yield, or incidence of bacterial wilt within 700 feet of light traps. Interpretation could be that light traps are as effective as insecticides; however, combined effects of cultural practices, varieties grown and environmental factors really eliminate need for beetle control, except under optimum conditions for insect multiplication.

Blacklight traps are being effectively used for population surveys of sod webworms (various Crambus sp) and show some promise for control. Investigations were begun of possible use of electric grids with dusk-to-dawn

security lights for killing insects. Insect attraction is directly related to ultraviolet output from the lamps and their refractors. Clear, color-improved white, and deluxe-white 175-watt G.E. mercury-vapor lamps proved equally attractive to insects. At 20-foot lamp elevations insects tended to become windborne and could not direct themselves to the lamps at wind velocities above three to five miles per hour.

Engineers studying ultra low volume application of insecticides at Wooster, Ohio, used an outside mixing air nozzle with increased air flow modification to apply Guthion ULV, Cygon 2E, Meta-Systox-R ULV and Malathion ULV at dosages of 6 to 24 avdp. oz. per acre. The same insecticides were applied in hydraulic spray at 150 gal. per acre. Meta-Systox-R controlled turnip aphid and green peach aphid on peppers and potato aphid and two-spotted spider mite on eggplant when applied by both types of equipment. Control of insects by other materials on 10 vegetables treated was not obtained by either type application equipment. Study of physical properties vs. temperature shows flow rate can vary 5 to 19 percent with 5° F change in temperature of some ULV insecticides. Wettable powders added to spray formulation at 66 times normal concentration increased volume 10 percent. Violent hydraulic agitation increased some temperatures 10° F and volume 25 percent in five minutes. Normal, 33X, and 66X sprays were applied to randomized plots of Red Rome Beauty and Cortland apple trees averaging 17 feet in height. Scab and insect control was satisfactory in all plots. Data on control of European red mite was inconclusive.

In tests with trailing boom sprayer at Aurora, Oregon, mixed dusts bridged in the hopper where individual dusts flowed readily. Mechanical agitation mounted on the hopper lid overcame this problem. A vertical rotating shaft with piano wire spines inserted broke up the lodged dust. Gate agitation and compressed air fluidizing was insufficient.

F. Foreign Research Under Public Law 480 Funds

Engineers studied the application of air jets with a vortex to improve penetration of air-borne insecticide sprays into dense foliage of citrus trees at the Volcani Institute of Agricultural Research, Rehovot, Israel. Tests showed no more energy is needed with the vortex air stream or swirling jet sprayer developed than with a regular, flat airstream sprayer for the same mean spray penetration into a tree. Significant differences were found in volume of spray in some parts of tree. The performance characteristics of the sprayer as modified were determined. A formula was developed for describing the droplet size range with different sprayer capacities and pressures. Tests were made with 200, 275, and 400 micron nominal size droplets. The effect of droplet size on spray penetration into the tree was highly significant with regular air-blast sprayers. Smaller size gave poor recovery and larger size gave poor penetration. The intermediate size gave fair distribution. Comparisons between regular air-blast and swirl jet sprayers were made with intermediate size droplets. The distribution with the swirl jet was a little more uniform from outside to inside of tree, but the settling at top and bottom of tree was much poorer.

Publications - USDA and Cooperative ProgramsSpray Studies

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Vegetables

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IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF
FRUIT AND VEGETABLE CROPS
RPA 304

Agricultural Engineering Research Division, ARS

USDA and Cooperative Program

<u>Location of Intramural Work</u>	<u>Scientist</u>	<u>Man-years FY 1968</u>
Kansas (Manhattan)	CO ₂ Enrichment	1.0
Maryland (Beltsville)	Plant Growth Chambers	2.6
	Total	3.6

Problems and Objectives

One means of increasing the growth-efficiency of existing plant material is to optimize the environmental conditions. Much fundamental information is still needed about the effects on growth of particular environmental factors, particularly light (and other radiant energy) and gaseous components of the atmosphere. Interactions among these factors are not yet fully understood and information about response differences between plant species is limited.

Engineering objectives of the research include development of design criteria for:

1. Equipment and control systems for applying CO₂ to plants by using carbonated water and other sources.
2. Structures and related equipment for controlling plant environments.
3. Lighting, electrical equipment, and controls to modify environment for plant production.

Progress - USDA and Cooperative Programs

A. Carbon-Dioxide Enrichment

In cooperative work with the Kansas Agricultural Experiment Station, Manhattan, work in greenhouses using carbonated water mists continued to show improved growth of chrysanthemums as compared to plants misted with tap water. Differences were less in cooler greenhouse environment. Similar studies with leaf lettuce in temperature-controlled chambers indicate carbonated mist was most effective at 90° F., with 24 hours of light. The effectiveness was indicated by analysis of sugar and starch content of plants. Microscopic examination of plant stomata was initiated to determine physical response to environment.

Studies of optimum carbon dioxide levels at Beltsville, Maryland, in cooperation with Crops Research Division indicated that interacting factors need to be adjusted also. The light level, temperature, and nutrient application rate should be modified when the level of CO₂ is increased.

B. Plant Growth Chambers

At Beltsville, in the Phyto-Engineering Laboratory, visual observations of germination and seedling growth in temperatures between 65° and 105° F. indicate that young plants may respond to warm temperatures for early growth, like young animals. Temperatures used by the horticultural trade (75° F. night) are below the optimum for common species including petunia, ageratum, marigold, tomato, cucumber, and lettuce.

The Motion Meter, recently developed, has been modified to measure leaf thickness of alfalfa and will be used by alfalfa breeders, and others, to determine desirable leaf thicknesses for various plant uses.

Environmental control for small greenhouses is being studied in two "hobby" greenhouses which are heated and cooled by a domestic heat pump.

Publications - USDA and Cooperative Program

CATHEY, H. M., KLUETER, H. H., and BAILEY, W. A. Indoor gardens for decorative plants. Home and Garden Bull. No. 133, USDA. Dec. 1967.

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MECHANIZATION OF FRUIT AND VEGETABLE CROP PRODUCTION
RPA 305

Agricultural Engineering Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Maryland (Beltsville)	Vegetable	.5
Georgia	Vegetable	.2
California	Vegetable	1.0
Minnesota	Vegetable	.5
Michigan	Deciduous fruit	3.0
California	Deciduous fruit	.5
Washington	Deciduous fruit	2.0
Florida	Citrus	3.0
California	Citrus	1.0
California	Dates	1.0
Hawaii	Coffee	1.0
Louisiana	Tung	1.0
	Total	14.7

Intramural program is supplemented by extramural support representing 1 SMY at other U.S. institutions.

Problems and Objectives

Over one-fourth of all farm labor used for the production of crops in the United States is expended on fruits and vegetables. Although the number of man-hours has remained approximately static over the last 10 years, the percentage of the overall farm labor devoted to these crops has steadily increased. Thus the labor to produce the rapidly increasing volume has barely been offset by the labor-saving devices that have been put in use. The steady trend toward a decreasing supply of farm labor, particularly seasonal workers on which the growers depend most heavily, forecasts an even tighter labor market that can only result in reduced production if labor saving machines are not made available to the industry.

Major objectives of the research are to develop and evaluate alternative ways for:

1. The study of rheological properties of fruits and vegetables as they are related to mechanical harvesting and handling operations.
2. The development of machines and machine components to plant, cultivate, and harvest these crops.
3. The modification of trees and plants in order to facilitate the use of labor-saving devices.
4. The development of tillage units and the component equipment to minimize power requirements, reduce the number of field operations, and provide optimum seedbed and harvesting conditions.

Progress - USDA and Cooperative Programs

A. Vegetable

1. Planting and fertilizing equipment. Two special machines designed and constructed were used to put in six cooperative field experiments at two locations in the East. Four machines were used in seven locations for nine cooperative experiments in the West, and two special machines were used to put in five cooperative field experiments at two different locations in the Southeast. Potato yields in the East were increased 49 cwt./acre (14 percent) by firming seed pieces with double seed firming wheels in comparison to the common loose covering by hillling disks. Potato yields with 24-inch row spacings increased 65 cwt./acre and 92 cwt./acre (18 and 27 percent) when compared with 30- and 36-inch row spacings. Seed pieces per acre were kept constant for all three row spacings. Production per plant increased for all row spacings as plant spacing increased down the row. In 36-inch rows increasing spacing 50 percent from 11 inches to 16 1/2 inches increased yields per plant from 2.14 to 3.53 pounds or 66 percent. In comparing crop

response to liquid and dry fertilizers with three vegetable crops in Florida, one of the three crops showed highly significant increases in crop production for the dry-type fertilizer. No response on snap beans or peppers. With cabbage, 1,800 lbs./acre 6-8-8 dry fertilizer produced on the average 110 cwt./acre over the same fertilizer in liquid form (65 percent yield increase). This production was from all the fertilizer side-placed at time of planting. Split time of application gave similar response although the crop production was less (but not significantly less).

In Western Washington potato yields were significantly higher where fertilizer had all elements mixed and in two bands to the sides of the seed pieces in comparison to separate positions of NPK, or broadcast patterns (15.2 to 17.6 tons/acre or 16 percent increase). Application of small amounts of M-P as pop-up fertilizer (3N-6P added to 125N-166P lbs./acre) showed some benefit on sweet corn and snap beans overall as side placement or broadcast, but may be hazardous in dry weather.

2. Harvesting and Handling Equipment. Engineering research on mechanically harvesting vegetables was initiated in October 1967. The major effort to date has been planning, getting facilities for offices and shop, and in hiring personnel. Office space has been obtained in an existing USDA building and a new shop of approximately 40 x 100 feet is under construction. No active research such as construction of experimental equipment has commenced. Harvest and handling operations of crops such as celery, broccoli, and cauliflower have been observed. A library study of past and present research has been made and a file of available harvesting equipment has been compiled. A tentative list of crops was made, rating them for priority of research attention.

3. Harvesting potatoes. The results of an engineering cost study of producing and harvesting potatoes were analyzed and published. This publication should prove extremely useful to growers improving the efficiency of their operations. A study of multirow harvesting was completed and a manuscript prepared which discusses advantages and disadvantages. This information will permit growers to decide when to use multirow harvesting. A tool for root pruning was designed and constructed and will be used in research on "Hollow Heart" disease. Engineering research on potato harvesting was terminated during FY 1968.

B. Deciduous Fruit

1. Properties of bark and wood. A study of living apple tree limbs was made because the ability of fruit wood to transmit vibrations is one of the factors to be taken into account when branch and tree shakers are designed. The position of a number of limbs, subjected to natural and applied loads, was measured by means of a surveyor's level. The loads were removed and the amount of permanent displacement measured. Other limbs were held out of their natural position and the amount of force required to keep them there was measured periodically for a seven-month

period. The results are being published and will be of value in shaping and training trees for mechanical harvest. Permanent changes in direction of growth of limbs are affected by physical properties of the wood, growth of new cells, and growth of limbs toward light.

2. Status of harvesting mechanization. A study of the current state of fruit harvest mechanization was initiated during 1967 under contract with Fresno State College, California. A survey for background information was conducted with equipment manufacturers, Federal and State research groups, and fruit growers. At the present time there is essentially no mechanization of fresh fruit. Considerable interest has been shown in the use of picking aids and for complete mechanization with the expected shortage of dependable labor. The main concern is the possible loss of qualified labor rather than the cost of hand harvest.

3. Harvesting studies in California. Studies of mechanical harvesting of cling peaches show that recovery of marketable fruit with machines was within 2-6 percent of that for hand harvesting. The 1967 yield of trees pruned in 1966 was the same as for unpruned trees. Trials on mechanical harvesting of apricots showed that no selectivity (mature and immature fruit) can be obtained with shakers. However, canning quality was satisfactory. A multilevel picking platform for hedge-row pears was studied. Results showed (1) picking into a bag on the unit was unsatisfactory due to its awkwardness and work stoppage while emptying the bag, (2) picking into a transfer tube was awkward and interfered with the picker's movements, (3) picking into a six-inch wide conveyor on the railing in front of the picker was satisfactory and increased his rate 21 percent over ladder and bag picking. A study of methods for collecting shake-harvested olives showed that a simple canvas on the ground is satisfactory as far as bruise damage is concerned.

4. Harvesting of processing apples. A study showed the most effective frequency for shake harvesting apples is between 400 and 600 cycles per minute and the best stroke is 3 to 5 inches. A shaker especially designed for apples is being constructed. A straddle-type continuous blueberry harvester was used experimentally in harvesting semidwarf apple trees. A modified cherry harvesting unit was again used in harvesting 14,000 bushels of apples. In cooperation with an equipment company a prototype roll-out collecting unit was designed and constructed. Preliminary results look promising. In an attempt to develop another type of low cost collection unit, a simple trailer containing 7.5- x 7- x 2/3-foot boxes was designed and constructed. The trailer was covered with two sets of decelerator strips. Although tests showed the unit has some possibilities, other equipment under test shows more promise. Another system was devised where apples can be collected in four shallow slope-sided containers each 16- x 16-feet. The containers are moved from tree to tree by fork-lift trucks. Time studies indicate a two-man crew can harvest 10 trees per hour. Another machine for picking up apples from the ground was designed and built. It used rubber discs covered with foam plastic. Ninety percent recovery rates were achieved and the apples were gently handled.

5. Harvesting of fresh market apples. A four-picker-position, tree-wall harvesting aid for apples was completed. Time study observations were made of four experienced pickers. Harvesting times for bag picking of three different tree shapes were compared. Average harvest time of the crew was reduced by 26.7 percent when picking with no aids in a dwarf tree-wall as compared to standard trees. It was found that harvesting aids for a crew of human pickers will operate at maximum efficiency only when the tree-walls have been trained for maximum fruiting efficiency. This is due to the small amount (10 to 15 percent) of nonpicking time involved in the bag picking of dwarf tree-walls. As the height of tree-walls increases through the use of other than dwarf trees, multilevel harvesting aids will become more practical, but tree uniformity must still be stressed for maximum harvesting efficiency as well as maximum yields. Pressure tests show that the lowest yield pressure for Golden Delicious apples was 10 times higher than average yield pressure of the firmest polyfoams. Therefore, polyfoam materials can safely be used on positive transfer conveyors. Research on bin fillers showed that a bin with a movable bottom is not feasible.

6. Harvesting of sweet and tart cherries. A study of methods of handling cherries in water showed that aeration does not prevent scald and that under certain conditions it causes objectionable darkening of the fruit. Investigation showed that the temperatures of cherries on the tree can be lowered 10 degrees or more by spraying the trees with cold water. Doing so decreased pitter loss and increased product yield and makes mechanical harvesting of tart cherries on hot days possible. A study of layout and construction of orchard cherry cooling stations was made and a report published. A study was made to determine the practicability of buying and selling cherries by volume rather than weight. Size of fruit, maturity, number of attached stems, and nesting of cherries affect the relationship of weight to volume only slightly. Bruising and firmness of cherries greatly affect the relationship and can cause as much as 10 percent change in bulk density. The study shows that buying cherries by volume would have the advantages of low cost, less bruising, and rewarding growers who deliver unbruised fruit. A tentative regulation for permitting buying and selling by volume is being prepared. A two-year study was made to determine the effects of immediate brining of sweet cherries on quality, change in weight, change in size, stem detachment force, and firmness was completed. Both bruised (mechanically harvested) and nonbruised cherries and cherries with stems and without stems were included in the tests. The results show that for best quality, the fruit should be brined within one hour after harvest.

C. Citrus Fruit

1. Tree modification to facilitate harvesting. The severe hedging of mature Valencia and Hamlin orange and grapefruit trees into six-foot thick tree walls has produced consistently poor yields of fruit over the past three years. Eight-year-old Pineapple orange trees, hedged in February

1967, yielded 2.7 boxes per tree compared to 3.0 boxes per tree in unhedged trees on the same 15- x 14-foot tree spacing. Close spaced trees on beds in the East Coast area of Florida continue in a tree-wall-shaping program but have not come into bearing. Tree pruning experiments to improve the efficiency of the tree shaker-catch frame harvest system were completed this season. Pruning an access hole for the tree shakers and removal of "unshakeable" limbs did not increase the system efficiency significantly over simply raising the tree "skirts."

2. Fruit loosening studies. The metabolism of iodoacetic acid by orange leaves was studied. Fifty-three other chemicals were tested for their abscission-promoting activity on Pineapple and Valencia orange explants. Shaker harvest trials using abscission chemicals were continued in the field. Fruit removal, quality checks, and harvest time studies were made using ascorbic acid and a mixture of erythorbic and citric acids as abscission-inducing chemicals. Harvest rate of the tree shaker-catch frame system was increased 17 percent using ascorbic acid and 11 percent using the mixture of erythorbic and citric acids as preharvest sprays. Fruit removal was not increased, but the fruit received less damage and had fewer attached stems than the untreated fruit that was harvested. This phase of the research will continue to improve the economics of using preharvest sprays and verify results from season to season.

3. Harvesting for fresh market. Tree modification and deadwooding of Navel and Valencia oranges at Riverside and the Coachella Valley for use with canopy and limb shakers was initiated. Ascorbic acid and six other chemicals were studied for abscission promoting effects. Shake harvest tests on single-pick lemons and grapefruit in the Coachella Valley showed a fruit removal of 90 percent. Surface injury, rind oil spotting, and fruit with 1/2- to 3/4-inch stems are problems. A unit for destemming citrus was constructed and tests indicate it can remove 90 percent of stems from Navel oranges. A slatted surface consisting of small diameter tubing covered with insulation material shows promise for catching citrus. Tests of the experimental roller harvester indicate fruit size, roller spacing, and surface speed influence fruit detachment more than roller angle. Economic feasibility studies of mechanized citrus harvesting and man-positioners were made. Methods of maintaining fresh market quality of mechanically harvested citrus are being studied.

4. Harvesting for processing outlets. Several additional tree shaker units for citrus harvesting were manufactured and used. The air-blast harvester was developed into a complete harvest system by one company. The best auger diameter and spacing was determined and an 80-auger bank harvester is being constructed for test on Valencia oranges. The snapping shaker developed last year was tested on Valencia oranges to differentiate between the larger mature fruit and the small green fruit of next year's crop. The fruit removal differentiation was not significantly improved over the conventional inertia shaker, and the unit was abandoned. A privately developed foliage type shaker was tested on

Valencias with no better results than the snapping shaker. The prototype tree shaker-catch frame harvest system was given limited use by one processor in Hamlin oranges. Fruit was harvested and delivered to roadside for 26 cents per box compared to 36 cents per box for the hand-harvesting system in the same grove. A rubber fingered auger "brush" machine for picking up fruit from the ground was designed, built, and tested. The pickup conveyor did not operate well in dry sand and is being replaced with potato chain. A time study was made of different hand picking and drop methods.

D. Miscellaneous Fruit

1. Production of dates. Research aerial pollinization of dates was continued. About 500 acres were aerial pollinated at 1 1/2 quarts of pollen per acre on a two-day schedule. The yield and fruit set in 1967 for both aerial and hand-pollination were below normal and not as good as 1966 results. Based on temperature records for the past 60 years, only six percent of the years had average maximum temperature as cold or colder than 1967 and no other April on record was as cold as 1967. Studies are in progress to determine temperature-fruit set relationships. The application of pollen from harvesting towers and ground dusting rigs will also be investigated in 1968. Shaking tests to separate pollinated from unpollinated dates were unsuccessful. Sizing the fruit two to four weeks after harvest gave the best separation. Plastic rings were installed in 40 palms in an attempt to eliminate the tie down operation. The plastic rings did not keep their shape and steel rings will be evaluated in 1968.

2. Harvesting and handling of coffee. Improvements were made in the suspension, shaking action, and clamp of the circular motion shaker for harvesting coffee. Further research on mass harvesting equipment was discontinued and emphasis placed on hand-held picking aids. A number of electrically hand-operated shakers were developed by modifying reciprocating saws, hand drills, polishers, and chain saws. Various types of collecting devices were designed and tested--the best being a drop cloth with a raised edge on at least one side and a center emptying device. Field trials showed the equipment was highly satisfactory and six growers have made firm commitments to purchase shakers. Air blast equipment for leaf and trash separation and bounce equipment for separating mature and immature coffee were developed. Laboratory studies were made of the reaction of coffee tree laterals to circular motion vibration. A study to determine energy recovery rate of coffee cherries dropped on a steel plate was begun. The information acquired will be used to further develop equipment for separation of mature and immature fruit. Orchard modifications have been continued. Currently under study are trellising, rejuvenation, chemical growth regulators, and pruning methods.

3. Harvesting and handling of tung. Redesigned project-developed tung harvester to make it a self-propelled unit. This unit works more efficiently on the sloping, contoured rows than the previously developed

tractor-mounted model. An experimental stick remover on the harvester removed only about 20 percent of the sticks, with none under five inches in length being removed. In a test to determine whether herbicides could be used to control weeds and grasses in tung orchards, none of the four herbicides, each applied at two rates and two dates of application, gave satisfactory control for good harvesting conditions.

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CULTURE AND PROTECTION OF ORNAMENTALS AND TURF
RPA 906

Agricultural Engineering Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Commodity	Scientist Man-years FY 1968
Indiana (Lafayette)	Turf	0.5
	Total	0.5

Problems and Objectives

Modification of environment through control of soil temperature is an effective aid in both culture and protection of ornamentals and turf.

Engineering objectives are to:

1. Evaluate the performance of electric equipment for soil warming.
2. Determine design parameters for electric soil-warming systems and devise control systems to maintain desired temperature conditions.

Progress - USDA and Cooperative Programs

Various wire-insulating materials have been tested, the insulating effects of turf thatch and of plastic coverings compared, and the effectiveness of several time-rates of heating evaluated. The performance of three large-scale commercial installations is being observed and evaluated to define several fundamental relationships to work out management problems. This work is cooperative with Purdue University Agricultural Experiment Station and is supported by the Indiana Electric Association.

Investigations were continued at Lafayette, Indiana, to further check control systems and to develop a method for estimating energy use. Tests in Minnesota indicate snow cover is a major factor in the effectiveness of a turf heating program. A gradual reduction of heating during the winter was preferable to an abrupt termination of heating.

Publications - USDA and Cooperative Program

None